R. A. Laubengayer

Oct. 1949

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PROCEEDINGS

of the

Indiana Academy *of* Science

Founded December 29, 1885

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Volume 58

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E. ST. CLAIR GANTZ, EDITOR

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Spring Meeting
THE SHADES
May 14 and 15, 1948

Sixty-Fourth Annual Meeting
INDIANA UNIVERSITY
October 28, 29, and 30, 1948

Copies of the Proceedings may be purchased through the State Library, Indianapolis, Indiana, at $3.00 per volume. All items sent in exchange for the Proceedings and all communications to officers of the Academy, when their names and addresses are not known, should also be sent to the State Library.

Reprints of certain parts of recent volumes of the Proceedings are available for distribution as follows: copies of the constitution and by-laws (Vol. 44), and complete membership list (Vol. 56), may be secured by members elected subsequent to the publication of those volumes; copies of the codified list of duties of officers (Vol. 48) may be secured by officers, divisional chairmen, and chairmen of committees; and copies of the necrology can be supplied to relatives and friends of the deceased members. Inquiries concerning these reprints should be addressed to the Secretary of the Academy, Dr. O. B. Christy, Ball State Teachers College, Muncie, Indiana.

Reprints of technical papers in recent volumes can often be secured from the authors. They cannot be supplied by the State Library nor by the officers of the Academy.

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OFFICERS AND COMMITTEES FOR 1948

OFFICERS

President, Winona H. Welch, DePauw University
Vice-President, Mason E. Hufford, Indiana University
Secretary, O. B. Christy, Ball State Teachers College
Assistant Secretary, Donald E. Miller, Ball State Teachers College
Treasurer, W. F. Morgan, Indiana Central College
Editor, P. D. Edwards, Ball State Teachers College
Press Secretary, William A. Daily, Butler University

DIVISIONAL CHAIRMEN

Anthropology, Arthur B. Carr, Indianapolis
Bacteriology, M. S. A. Campbell, Indianapolis
Botany, H. J. Brodie, Indiana University
Chemistry, E. St. C. Gantz, Purdue University
Entomology, W. P. Allyn, Indiana State Teachers College
Geology and Geography, Floy Hurlbut, Ball State Teachers College
History of Science, S. S. Visher, Indiana University
Mathematics, L. H. Whitcraft, Ball State Teachers College
Physics, J. C. Hendricks, Franklin
Psychology, D. G. Ellson, Indiana University
Zoology, J. W. Baechle, St. Joseph's College

EXECUTIVE COMMITTEE

(Past Presidents, Divisional Chairmen, and Chairmen of Standing Committees)

W. P. Allyn, J. W. Baechle, C. A. Behrens, H. J. Brodie, M. S. A. Campbell, A. B. Carr, O. B. Christy, W. A. Cogshall, E. R. Cumings, W. A. Daily, J. J. Davis, C. C. Deam, E. F. Degering, W. E. Edington, P. D. Edwards, D. G. Ellson, H. E. Endres, R. C. Friesner, E. St. C. Gantz, W. G. Gingery, J. C. Hendricks, M. E. Hufford, Floy Hurlbut, Theodor Just, Eli Lilly, J. F. Mackell, E. G. Mahin, C. A. Malott, M. S. Markle, K. S. Means, M. G. Mellon, H. H. Michaud, D. E. Miller, W. P. Morgan, Naomi Mullendore, F. Payne, R. R. Ramsey, W. E. Ricker, J. W. Switzer, S. S. Visher, F. B. Wade, F. N. Wallace, Paul Weatherwax, Winona H. Welch, L. H. Whitcraft, J. S. Wright, T. G. Yuncker.

BUDGET COMMITTEE

(President, Secretary, Treasurer, Editor, and Chairmen of Committees on Fifty-Year Index, Junior Academy, Library, Program and Relation of Academy to State)

Winona H. Welch, DePauw University: O. B. Christy, P. D. Edwards, R. C. Friesner, W. G. Gingery, H. H. Michaud, W. P. Morgan, F. N. Wallace, Paul Weatherwax.

COMMITTEES

(Elected by the Academy)

Trustees of Academy Foundation (Term 4 years): Chairman, J. S. Wright, Eli Lilly and Co., Indianapolis (term ex. 1952); F. B. Wade (term ex. 1951).

Bonding of Trustees (elected annually): Chairman, R. C. Friesner, Butler University; Scott McCoy.

Research Grants (term 5 years); Chairman, T. G. Yuncker. DePauw University, (term ex. 1949); E. G. Mahin (1952), H. H. Remmers (1950), Paul Weatherwax (1951), J. S. Wright (1948), Winona H. Welch and O. B. Christy (ex officio).

STANDING COMMITTEES

(Appointed by the President, Chairmen named first)

Auditing: K. S. Means, Butler University; E. S. Elliott

Biological Survey: W. E. Ricker, Indiana University; W. P. Allyn, W. B. Barnes, H. J. Brodie, L. C. Cole, Fay K. Daily, H. O. Deay, R. C. Friesner, H. H. Michaud, H. H. Vogel, Winona H. Welch.

Fifty-Year Index: R. C. Friesner, Butler University, Nellie M. Coats, W. P. Morgan, F. N. Wallace, Paul Weatherwax.

Invitations: Naomi Mullendore, Franklin College; A. R. Bechtel, T. P. Irving, C. L. Porter, B. H. Smith, O. H. Smith.

Junior Academy: H. H. Michaud, Purdue University; N. E. Adams, W. P. Allyn, F. R. Elliott, E. Kintner, M. S. Markle, R. Earl Martin, A. Strickler, F. B. Wade, P. L. Whitaker.

Library: W. G. Gingery, Washington H. S., Indianapolis; Nellie M. Coats, R. C. Friesner.

Membership: J. E. Switzer, Indiana University; M. H. Ahrendt, Juna L. Beal, E. Byrne, Jr., M. Chanin, J. J. Davis, S. R. Esten, G. F. Hennion, L. B. Howell, J. L. Hyatt, Alma Long, J. A. Marling, A. H. Meyer, Bessie Noyes, A. E. Reynolds, J. E. Seybert, W. Shepherdson.

Necrologist: W. E. Edington, DePauw University.

Nominations: (Announced at Executive Committee Meeting in October.)

Program: Paul Weatherwax, Indiana University; W. B. Adams, W. E. Breneman, Charles Hire, F. C. Mathers, L. S. McClung, S. S. Visher.

Publication of Proceedings: P. D. Edwards, Ball State Teachers College; R. C. Corley, Paul Weatherwax.

Relation of Academy to State: F. N. Wallace, State Dept. of Conservation; E. Y. Guernsey, H. J. Reed, J. S. Wright.

Representative on Council of A.A.A.S.: E. F. Degering, Purdue University.

Resolutions: J. F. Mackell, Indiana State Teachers College, F. B. Wade, J. S. Wright.

MINUTES OF THE SPRING MEETING

The Shades State Park

May 14, 15, 1948

President Welch called the Executive Committee meeting to order at 4:40 p.m., Friday, May 14, in the pavilion, with 25 members present.

The officers and committees reported as follows:

Treasurer. W. P. Morgan reported as of January 1, 1947, receipts, $5,247.65, with disbursements $2,917.89, leaving a balance of $2,329.76. This balance includes $1,000 in gifts for completion of the Fifty-year Index.

Editor. P. D. Edwards made the following report:

Bill for reprints of articles in Volume 56 amounting to $746.25 was received March 22, checked, approved, and forwarded to the President for her approval and payment by the Treasurer. Of this amount $592.34 will be recovered from the authors.

Part of the copy and requisition for printing and engraving of Volume 57 was taken to the bureau of printing December 29. To date, May 14, it has not been possible to secure the necessary purchase orders since the balance to the account of the Academy is less than the estimated cost of Volume 57.

Relations of Academy to State. Frank Wallace reported that there was a possibility of receiving funds from the Governor's Emergency Fund, to meet the deficiencies of the 1947 proceedings.

Fifty-year Index. R. C. Friesner reported that 70 per cent of the material was ready for publication.

Library. Walter Gingery reported that forty new serial publications have been listed since October, 1947. These included several foreign publications.

Mr. Wallace reported that there was a possibility of receiving a special room to house the Academy Library, in the State Library, when several rooms would be vacated within the next few years.

Membership. J. E. Switzer submitted 31 applications for membership. These were duly elected.

Program. Paul Weatherwax explained the trips which had been planned over the park area the next day.

Flower Committee. Dr. Friesner recommended that the Academy take steps to change the State Flower from the Zinnia, to the Wild Aster. (Aster novae-angliae) The motion was made that the committee proceed to try to obtain legislative action to make this change in the State Flower.

New Business. Dr. P. D. Edwards presented the matter of raising annual dues for membership. He pointed out that it would be necessary to change the constitution, then moved that the President appoint a committee to study the problem and present the matter in writing at the October meeting.

Stephen S. Visher presented the matter of handling reprints, and moved that the authors pay for all reprints received. Dr. Edwards seconded the motion which was carried.

A. W. Lefler, of Purdue, presented a plan, worked out by Lark-Horovitz, in which the Academy would sponsor a Science Speakers Bureau. The plan was to get the problems of Science closer to the people of Indiana by obtaining outstanding speakers for public occasions. Dr. Friesner moved and Dr. Edwards seconded the motion that such a committee be appointed by the President for study and recommendations made at the October meeting.

Mr. Howard Michaud presented plans for selecting Indiana Science talent from High School seniors and these would be eligible for scholarships in State Colleges or Universities where Science Fellowships would be offered.

The meeting adjourned at 5.45 p.m. Following the dinner, interesting pictures were shown and talks given concerning the Shades by Frank Wallace, and Fabian J. Frisz, manager of the Inn. 107 members attended the dinner.

MINUTES OF THE EXECUTIVE COMMITTEE

Bloomington, October 28, 1948

The Executive Committee was called to order by President Welch in Room E of the Memorial Union Building of Indiana University, at 7:30 P.M. The minutes of the Spring Meeting, held at the Shades State Park, were read and approved. The reports of officers and committee representatives were presented and accepted as follows:

Academy Trustee. John S. Wright, chairman of the Trustees of the Foundation Fund, reported as follows for the year 1947-48.

Balance from previous year	$ 176.34
Receipts	209.55
Total	$ 385.89
Expenditures	
Union Trust Co. Fee	10.48
Photostat copy of resolutions	.40
Cash Balance as of October 28, 1948	$ 375.01

Assets in the Fund as of September 30, 1948

Five $1,000 U. S. Savings Bonds Series "D"—Cost	$ 3,750.00
$6,900 U. S. Treasury Bonds Series "G"—Cost	6,900.00
Six Shares Standard Oil of Indiana Common Stock Par	150.00
Total at Par or Cost	$10,800.00

Treasurer. W. P. Morgan presented a tentative financial report for the period from January 1, 1948 to September 1, 1948. His final report, approved by the Auditing Committee at the end of the year follows:

Receipts

Balance on hand January 1, 1948	$2,329.76	
Dues and initiation fees	1,205.00	
Refund for research from A.A.A.S.	150.00	
Designated gift	200.00	
Author's reprints Vol. No. 56	441.86	
Author's reprints Vol. No. 57	116.56	
Publications sold	3.00	
		$4,446.18

Disbursements

1—Program Committee	$ 206.08
2—Editor Vol. No. 57	200.00
3—Expenses of Secretary	67.91
4—Expenses of Treasurer	94.50
5—Mailing Proceedings	84.00
6—Stationery	38.11
7—Publications for Library	49.58

8—E. J. Hecker (printing for Index)	12.30		
9—Bookwalter Co. (Index)	770.15		
10—Jr. Academy expenses	17.73		
11—Author's Reprints Vol. No. 57	670.40		
12—Author award 1948 C. A. Malott	25.00		
13—Author award 1948 Ed. F. Degering	25.00		
14—C. P. Hickman research grant	75.00		
15—W. E. Thrun research grant	18.75		
16—C. P. Hickman research grant	37.50		
17—Expenses to five officers as directed by action of 1947 Executive Com.	100.00		
19—Returned checks	4.00		
		$2,496.01	
*Balance on hand		1,950.17	
			$4,446.18

* Balance includes $700.00 designated for the preparation for publication of the "Indiana Men of Science."

(Signed) W. P. Morgan, *Treasurer*
(Signed) Karl S. Means,
S. E. Elliott, *Auditors*

Auditing Committee. Dr. Means was not present, but Dr. Wright and Dr. Morgan reported the accounts of the Academy Trustees and of the Treasurer to be in good order.

Bonding Committee. Dr. Friesner reported that the Academy is bonded in advance for two years.

Editor and Publication of Proceedings. Dr. Edwards reported that the publication of Vol. 57 has been delayed. It is hoped that it can be published yet in 1948.

Research Grant. Dr. Yuncker reported five grants for the year 1948, totaling $400. These grants were made to J. E. Potzger, $50; A. E. Reynolds, $75; W. E. Thrun, $75; Robert Drummond, $50; and C. P. Hickman, $150.

Biological Survey. W. E. Ricker reported a continuation of the activities of the committee.

Fifty-Year Index. Ray C. Friesner reported that the index has been printed and that copies are being mailed to members upon receipt of their requests. The total cost of 2000 copies of the publication was $3,977.95.

Library Committee. Walter Gingry reported that a number of serial titles, new to the library, have been added during the year—43 in all. He also reported an increased use of the library.

Press Secretary. W. A. Daily reported the usual press releases and printed announcements were sent to all the colleges and universities in the state. Photographs of all but two past presidents of the Academy have been secured for the files.

Membership. J. C. Switzer presented a tentative report.

Junior Academy of Science. Howard H. Michaud reported an increased interest during the year. Twenty-five clubs representing 20 different schools are active.

The program for the 1948 Meeting promises to be unusually good, with 12 students on the program.

Special arrangements have been made to provide overnight accommodations for Friday night at McCormick's Creek State Park, for club members who are attending the meeting Saturday.

The outstanding achievement for the year was the Indiana Science Talent Search conducted in cooperation with the science clubs of America. Nineteen of the 21 state winners are now attending college; majoring in science, medicine, or engineering.

Relation of Academy to State. Frank Wallace reported the State is paying $2,500 toward the publication of the Index. The State is also cooperating in the publication of Vol. 57.

Mr. Wallace and Dr. Edwards recommended that we ask the Budget Committee for $3,500 for each of the next two years, toward the publication of the Proceedings. There was general agreement on this amount.

Relation of Academy to A.A.A.S. E. F. Degering reported that he represented the Academy at the Council meeting at Washington, D. C., September 13. He reported an excellent meeting.

Relation of Academy to State Academies of Science Conference. Dr. Degering reported that an interesting meeting was held September 17 in Washington, D. C.

Nomination Committee. Dr. Welch announced the members of the committee to be R. R. Ramsey, C. A. Behrens, and T G. Yuncker. They recommended for election as Fellows the following: Nellie M Coats, State Library; Clyde G. Culbertson, I. U. Medical Center B.Z.; D. E. Miller, Ball State Teachers College, Bo.Z

Old Business. Will E. Edington reported that progress is being made in securing biographical data on men who were prominent in science in Indiana before 1900. It may take several years to complete the work, in order to have completeness and accuracy.

Dr. Friesner reported for the State Flower Committee. The recommended change from Zinnia to Aster *(novae-angliae)* will be presented to the legislature.

Dr. Degering reported for the "Speaker Bureau Committee." The Committee feels that it would take about $1,500 to initiate the program, and perhaps $500 per year to keep it going thereafter. A motion was passed that a committee of 3 to 5 members be appointed to investigate the problems further.

Committee on Editorial Problems. Dr. Edwards presented a statement of the condition of finances as it relates to the publication of the *Proceedings.* The following suggestions were made by the committee.

1. As soon as possible after the completion of the printing of Vol. 57, the bill should be presented and an effort made to have the state legislature grant a deficiency bill to pay the deficit and restore us to a current basis.
2. Plan to hold costs of future volumes to the amount of the appropriations *or* pay the excess from Academy funds.

3. Support a request to the legislature to change the 1947 law relating to purchases so that printing may be ordered if the estimated cost does not exceed the amount which will be in the account when the printing is completed.

Dr. Edwards reported for the Committee on Dues. The committee proposed the following amendments:

Amendments to Constitution

1. Article II. Section 2. Third sentence changed to read: New members shall pay an admission fee of $1 and the annual dues for one year.

2. Article II. Section 4. Paragraph 3. Changed to read: Each applicant club, upon meeting Academy affiliation requirements, payment of an entry fee of $1 and an affiliation fee equal to the annual dues of annual members, and upon recommendation of the committee in charge, shall receive for its files a certification of membership signed by the President, Secretary, and Treasurer of the Academy. Such affiliation shall continue upon payment of annual affiliation fee so long as the club continues to meet requirements of affiliation. Each affiliated club will receive one copy of the Proceedings of the Indiana Academy of Science.

Amendment to By-Laws

1. Article V. Section 2. (New section)

The annual dues shall be determined by the Executive Committee.

A motion was passed that the Executive Committee recommend that these amendments be presented at the business meeting Friday.

New Business. Mr. Wright presented the following resolutions, which were approved:

RESOLUTION AUTHORIZING THE TRUSTEES OF THE RESEARCH ENDOWMENT FUND OF THE INDIANA ACADEMY OF SCIENCE TO CONFORM TO THE PRESENT INDIANA LAW REGARDING INVESTMENT TRUST FUNDS

WHEREAS, the rules governing the investment of the Research Endowment Funds were written in 1919 and were the same as prescribed by the Indiana law of that time for the legal reserves of life insurance companies; and

WHEREAS, the present law is less strict, nevertheless safeguards the principal of trust funds; therefore be it

RESOLVED: that the first three lines of the section on "Investments" now reading—

> "Investments—
>
> The trustees shall keep all research endowment funds invested in standard securities, such as are prescribed by law in Indiana for the investment of the legal reserve of life insurance companies."

be changed to read as follows:

> "The trustees shall keep all endowment funds invested in standard securities such as are permitted by law in Indiana for the investment of TRUST FUNDS.

John S. Wright presented the following resolutions regarding the Research Endowment Fund:

WHEREAS, the rules and regulations governing the management of the Research Endowment Fund have not been reprinted since their original publication in the Academy Proceedings for 1919; and

WHEREAS, it is the duty of the Research Committee to cooperate with the trustees of the Fund and the Executive Committee in giving suitable publicity to the Fund and to invite contributions; therefore be it

RESOLVED: that the trustees and Research Committee be authorized to have reprinted a suitable statement of the origin and of the purposes of the Fund and of the regulations governing its administration for use in answering inquiries and in the promotion of interest in the Fund; and further be it

RESOLVED: that this statement incorporate any changes in the management of the Fund that may be authorized by resolution at this meeting.

A motion was passed that the Union Trust Company, 120 East Market Street, Indianapolis 9, Indiana, be authorized to notify the United States Treasury and others who send dividend checks to the Indiana Academy of Science Research Endowment Fund, that all checks payable to this fund should be forwarded in care of this Trust Company fiscal agent and custodian of the Fund.

Dr. Friesner presented the matter of keeping the accumulated Index up-to-date. There was general agreement that this should be done.

A motion was passed that the Executive Committee authorize the beginning of work on a ten year Index and that a committee be appointed to carry on the work.

Mr. J. S. Wright was elected to succeed himself as a trustee. He was also elected to succeed himself as a member of the Research Grant Committee for a five year term.

Dr. R. C. Friesner and Scott M. Coy were elected to continue as the committee on the bonding of trustees.

The meeting was adjourned at 10:15 p.m.

MINUTES OF THE GENERAL SESSION

BLOOMINGTON, OCTOBER 29, 1948

Dean John W. Ashton, College of Arts and Sciences, delivered the Address of Welcome. President Welch responded in behalf of the Academy.

W. E. Edington presented the necrology consisting of the following names: Emil Dietz, Milton Matter, Charles Knip and Gladys Knott.

Minutes of the Executive Committee meeting of October 28, 1948 was read by the Secretary and approved by the Academy.

Dr. Konrad Birkhaug of New York State Department of Health delivered an interesting and informational lecture on Experimental and Clinical Aspects of BCG Vaccination against tuberculosis.

The resolutions presented by J. S. Wright at the Executive meeting were read and approved.

The following members were elected to fellows:
Nellie M. Coats, State Library; Clyde G. Culbertson, Indiana University Medical Center; and Donald Miller, Ball State Teachers College.

At the annual dinner in the Alumni Hall, Union Building, J. E. Switzer presented 79 applications for membership. These were duly elected.

Dr. Ramsey, chairman of the Nominating Committee, presented the following names for officers:

President, Charles L. Porter, Purdue University; *Vice-President*, Stephen S. Visher, Indiana University. *Secretary*, O. B. Christy, Ball State Teachers College; *Treasurer*, W. P. Morgan, Indiana Central; *Editor*, P. D. Edwards, Ball State; *Press Secretary*, W. A. Daily, Butler University.*

The Divisional Chairmen elected in the sectional meetings for 1949 were announced as follows:

Anthropology—William Wallace, Indiana University; *Bacteriology*—Robert F. Ervin, Notre Dame; *Botany*—R. A. Laubengayer, Wabash College; *Chemistry*—William G. Kessel, Indiana State; *Entomology*—Edward Kintner, Manchester College; *Geology and Geography*—Preston McGrain, Ind. Flood Control & Water Comn.; *History of Science*—Paul Weatherwax, Indiana University; *Mathematics*—Paul Overman, Purdue University; *Physics*—Ancil R. Thomas, Valparaiso University; *Psychology*—E. J. Asher, Purdue University; *Zoology*—Murvel R. Garner, Earlham College.

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* Dr. Edwards declined the nomination as Editor and E. St. C. Gantz, Purdue University was elected.

Dr. P. D. Edwards reported for the awards committee as follows:

> Clyde A. Malott, Indiana University to receive the E. R. Cumings award in Geology and Dr. Edward Degering, Purdue University, the Wm. A. Noyes award in chemistry.

James F. Mackell expressed the appreciation of the Academy to the faculty and administration of the University for the excellent manner in which the members were received.

The chairman of the Invitations Committee announced that the invitation from Wabash College for the 1949 Fall Meeting had been accepted.

Dr. James F. Mackell, Chairman of the Resolutions Committee read the following report:

> "The Committee on Resolutions for the sixty-fourth annual meeting of the Indiana Academy of Science begs to submit the following:
>
> 1. The Academy wishes to express its sincere appreciation for the splendid program arranged by the program committee headed by Professor Paul Weatherwax. Mr. Prevo Whitaker of the University School is also commended for his part in arranging the program for the Junior Academy. The Academy wishes to thank Mr. Charles Weatherwax for helping to make the speakers table more attractive with the beautiful floral centerpiece.
>
> Dr. Michaud is commended for his untiring efforts to make the Junior Academy a vital part of our Academy and for keeping our young Indiana people abreast of the times in scientific thought.
>
> 2. To the Indiana University Convention Bureau and to the Administrative officers of the University, the Academy extends its sincere thanks. Lodging rooms for our members were secured, meeting rooms were graciously provided, and we are especially grateful for the provision made for this banquet room and this excellent Academy dinner.
>
> Indeed our hosts have made us feel very much at home on our own State University Campus."

Dr. Mason E. Hufford, Vice-President, presented President Winona H. Welch, who read a well prepared paper on, "Mosses And Their Uses."

The Sixty-fourth Annual Meeting of the Indiana Academy of Science with a general attendance of approximately 375 and a dinner attendance of 146, was adjourned.

O. B. CHRISTY, *Secretary.*

TAXONOMISTS MEETING

Dr. Naomi Mullendore, Chairman. The Plant Taxonomists held their annual meeting on Saturday morning. Professor Daniel Den Uyl was elected chairman for 1949.

INDIANA JUNIOR ACADEMY OF SCIENCE

Officers for 1948:

President: Donald Krebes, Science Club, William A. Wirt High School, Gary.

Vice President: Robert Craig, Biology Club, Lew Wallace High School, Gary.

Secretary: Jane Niles, Junior Academy of Science, Elkhart High School, Elkhart.

Members of the Council: Roy McKee, (1944-1948); Ruth Wimmer, (1945-1949); Darl Wood, (1946-1950); G. Donald Klopp, (1947-1951); Evelyn Wagoner, (1948-1952).

PROGRAM OF THE SIXTEENTH ANNUAL MEETING

October 30, 1948

Auditorium, University High School, Indiana University
Bloomington, Indiana

9:00 a. m. Exhibits, University High School Gymnasium

10:00 a.m. Morning session, Auditorium, University High School

General session, Donald Krebes, presiding.

Greetings, Prevo L. Whitaker, University High School.

Reading of minutes of the 1947 meeting, read by Robert Craig, Vice President.

Papers by club members.

1. "Experiments with a Radio Frequency Oscillator," Charles B. Ellis, Junior Academy of Science, University High School, Bloomington.

2. "Atomic Fission and Energy (illustrated)," Dick Miller and Virginia Horon, Science Club, Mishawaka.

3. "Experiments with Dry Ice," Donald Goss and Ted Logan, Phi Chem Club, Elmhurst High School, Fort Wayne.

4. "Atomic Age," Arleen Scheer, Science Club, William A. Wirt High School, Gary.

5. "Blood," Margaret Overbeck, Science Club, William A. Wirt High School, Gary.

6. "The Sand Dunes of Indiana," Tom Moon, Junior Academy of Science, Central High School, South Bend.

1:15 p.m. Afternoon session, Auditorium, Social Science Building,
Indiana University

Business session

1. "The New Castle Science Fair," Marjorie Tapscott, Biology Club, New Castle.

2. "Indian Relics," Robert Burch, Biology Club Lew Wallace High School, Gary.

3. "Birds and their Habits, (illustrated)," Judith Douthitt, National Scientific Honor Society, Bloomington High School, Bloomington.

4. "Regarding New Drugs," Mary E. Howard, 1948 Indiana State Science Talent Search Winner, Indiana University.

5. "Some Ear Marks of Glacial Period Drainage Systems," Thomas Todd, Chemistry Club, Shortridge High School, Indianapolis.

6. "The Indiana State Science Talent Search," Howard H. Michaud, State Sponsor, Purdue University.

MINUTES

The sixteenth annual meeting of the Indiana Junior Academy of Science was held Saturday October 30, 1948 in the auditorium of the University High School, Indiana University, Bloomington.

The meeting was called to order at 10:05 a.m. by the president Donald Krebes, Science Club, William A. Wirt High School, Gary, by introducing his fellow officers as follows: Vice president, Robert Craig, Biology Club, Lew Wallace High School, Gary, and Secretary, Jane Niles, Junior Academy of Science, Elkhart High School, Elkhart. The roll call of active clubs was read. An attendance of one hundred and forty five members, visitors and sponsors was registered. The minutes of the 1947 meeting were read by the vice president, Robert Craig, while Jane Niles recorded the minutes of the meeting. Mr. Prevo Whitaker, Science teacher at the University High School, welcomed the Junior Academy and expressed thanks to the Biology Club of New Castle for planning the overnight accommodations for clubs and sponsors at one of the group camps at McCormicks Creek State Park, Spencer.

The first speaker on the program, Charles B. Ellis, Junior Academy of Science, University High School, Bloomington, explained the operation of a radio frequency oscillator. He expressed enthusiasm for his hobby and stated that he hoped to continue with his studies in the future.

A team composed of Dick Miller and Virginia Horon, Science Club, Mishawaka, illustrated atomic fission and energy, using lantern slides. The structure of the atom, the relationship between plutonium and uranium and the opportunities for wise use of atomic energy were presented.

The Phi Chem Club, Elmhurst High School, Fort Wayne, represented by Donald Goss, Ted Logan and several assistants, demonstrated some practical and impractical uses of dry ice. A hammer was made from frozen mercury; kerosene was solidified to form a candle and a fire was extinguished with a dry ice and water extinguisher. All in all, it was a very colorful demonstration.

The question of atomic energy was discussed by another club member, Arleen Scheer, Science Club, William A. Wirt High School, Gary. After describing the development of and the destruction caused by the atomic bomb, her conclusion was, "The only answer to the atomic question is to live in one world, peaceably."

The president then introduced Margaret Overbeck, Science Club, William A. Wirt High School, Gary, who presented a talk on blood. She discussed blood plasma and many diseases of the blood.

The last speaker in the morning session was Tom Moon, Junior Academy of Science, Central High School, South Bend, who took us on a delightful excursion to the sand dunes of northern Indiana. He accompanied his descriptions of some of the plant and animal associations found in the dunes with beautiful kodachrome slides and closed with a cordial invitation to visit the beauty of the dunes.

The morning session was adjourned at 11:45 a. m.

The afternoon session was called to order by the chairman in room 100, Social Science Building, Indiana University, at 1:30 p. m. The first item of the business session was the election of new officers. A slate was presented by the council. The results of the election were as follows for the officers for 1949:

President: Richard Elzay, Phi Chem Club, Elmhurst High School, Fort Wayne; *Vice President:* Tom Moon, Junior Academy, Central High School, South Bend; *Secretary:* Marjorie Tapscott, Biology Club, New Castle High School, New Castle.

It was next announced that the Junior Academy Council had selected Mr. Max Forsyth, sponsor of the New Castle Biology Club, to succeed Mr. Roy McKee as the new Council member to serve from 1948 to 1953.

Robert Burch, Biology Club, Lew Wallace High School, Gary, opened the afternoon program with a talk on Indian relics. He had a fascinating collection of Indian arrow heads, bird points and small pieces of Indian pottery from many parts of the United States. He believes this to be a fine hobby as archeology is one of our important fields for investigation.

Mary E. Howard, 1948 Indiana State Science Talent Search winner and now attending Indiana University spoke on her favorite topic "New Drugs." She explained how streptomycin had been used to cure many diseases which were thought incurable. She spoke of the great progress that has been made in using vitamin E in the cure of heart disease. She is studying at Indiana University to become a laboratory technician.

The president next presented Marjorie Tapscott, Biology Club, New Castle. Marjorie gave a summary of their New Castle Science Fair held last spring. Good publicity brought visitors from many other schools. The judges for the fair included local people and representatives from several surrounding colleges. The one hundred and ten entries included some standard laboratory equipment, but home made equipment added much interest because of its originality. The Science Fair was made realistic to the group through the showing of colored motion pictures taken by the physics teacher at the New Castle High School.

Judith Douthitt, National Scientific Honor Society, Bloomington High School, Bloomington, showed slides of bird adaptations and explained how these adaptations fitted the birds in their environment.

Some Earmarks of Glacial Period Drainage Systems were then discussed by Thomas Todd, Chemistry Club, Shortridge High School, Indianapolis. An area from Anderson to Ingle was studied. Twenty foot drillings were made in bogs near Fairmont and although detailed analysis had not been made, they believe these bogs to be glacial deposits. Using colored movies taken on a field trip through these bogs last spring, the speaker described the bog flora. The group plans to continue the project next spring.

The last speaker of the meeting was Howard H. Michaud, State Sponsor, Purdue University. Professor Michaud spoke on "The National and State Science Talent Search." The National Science Talent Search selects forty winners who are given a trip to Washington, D. C. From this group two national winners each receive a four year college scholarship of $2,800 and $2,000 respectively. Eight more winners receive $400 each and $3,000 additional in scholarships is awarded at the discretion of the judges.

Last year Indiana had seventy-five entries who completed the requirements. Margaret M. Sawyer of Terre Haute received the trip plus one hundred dollars. Theodore Hopkins, Indianapolis, Joseph Harris, Evansville, Oscar Beumel Jr., Evansville, and Donald W. Zimmerman, Logansport, received honorable mention in the national competition. Of the seventy-five entries, a group of twenty-one students were chosen as the top ranking contestants in the state science talent search. These winners were offered scholarships to various colleges and universities of Indiana. Several winners received Indiana scholarships and more than half are attending colleges of the state. A number of the winners are enrolled in schools of other states on scholarship grants.

The eighth annual Science Talent Search will be conducted this year by the Westinghouse Science Talent Search in cooperation with the Science Clubs of America.

The president announced that the Council had selected Ted Logan, Elmhurst High School, Fort Wayne, as the "best boy" of the year and Marjorie Tapscott, New Castle, as the "best girl" of the Junior Academy. They will receive a year's honorary membership in the American Association for the Advancement of Science and also are invited to attend the National Junior Scientist's Assembly meeting in Washington, D. C. during the last week of December.

After expressing his thanks to those who took part in the program and to everyone who attended the president adjourned the meeting at 3:30 p. m.

EXHIBITS

Photographs: Camera Club, Sullivan High School, Sullivan, Ruth Hinkle, Sponsor.

Indian exhibit, Leaf booklets, Insect collection: Biology Club, Lew Wallace High School, Gary, Lola Lemon, Sponsor.

Physics apparatus and experiments: Phi Chem Club, Elmhurst High School, Fort Wayne, Ruth Wimmer, Sponsor.

Amphibian's of St. Joseph's County: Junior Academy of Science, Central High School, South Bend, Arthur Smith, Sponsor.

Lantern slides of special interests: National Scientific Honor Society, Bloomington High School, Bloomington, Harold Stewart, Sponsor.

Song recordings and kodachrome projections of birds: Biology Club, New Castle High School, New Castle, Max Forsyth, Sponsor.

Polished wood samples, Frog dissection, Insect collections: Junior Academy of Science, University High School, Bloomington, Prevo L. Whitaker, Sponsor.

Bulletins, Science helps for teachers: Display by the State Sponsor.

NEW MEMBERS OF THE YEAR 1948, INDIANA ACADEMY

Alexander, Mr. Paul Stephen, Indiana Central College, Indianapolis 3 — Bo, Z

Ball, Miss Henrietta S., Centennial School, 6th and Bronn, Lafayette — GS
Barber, Mr. Leonard Cretes, P. O. Box 191, Washington — Bo
Bower, Miss Esther, 306 West State Street, Fortville — Bo
Brey, Mr. Wallace S., Jr., 701 E. Seminary Street, Greencastle — Ch
Britz, Mr. Edwin J., Jr., 1362 N. Ewing Street, Indianapolis 1 — Ph
Brown, Miss Lucy Alace, R. 1, Vevay — Bo
Burroughs, Mr. John D., 119 Columbia Street, West Lafayette — Bo
Bushey, Dr. Clinton J., Upland — E

Carpenter, Mr. Irvin, Jr., 140 S. Salisbury, West Lafayette — Bo
Castro, Mr. Elias Adis, Anthropology Dept., Indiana University, Bloomington — A
Cedars, Miss Mary Elizabeth, 2200 N. Washington, Roosevelt School, Kokomo — G
Chandler, Mr. Leland, Friendship — Z
Christian, Mr. Howard H., 547 Prospect St., Westfield, New Jersey — Z
Clark, Miss Ann, 511 W. Columbia, Oakland City — Ba
Clark, Mr. Herbert, Jr., Route 2, Box 483, Terre Haute — Bo
Clem, Miss Gladys Marie, Eli Lilly & Co., Indianapolis 6 — Ba
Clevenger, Miss Sarah Beth, 717 S. Henderson Street, Bloomington — Bo
Cockran, Mr. Glenn Ray, 1216 Hendricks St., Anderson — C
Coffing, Miss E. Charlene, Eli Lilly & Co., Indianapolis 6 — Ba
Colby, Mr. Alonso Clark, Room 416, Indiana State Library Bldg., Indianapolis — G
Collier, Miss Patricia A., 1830 Clinton Street, Rockford, Illinois — Ba
Coulombre, Mr. Alfred Joseph, Wabash College, Crawfordsville — Z
Crane, Mr. William Earl, Fountaintown — C

Dean, Mr. Russell, 157 Austin Avenue, Rensselaer — Ph
Dreiling, Rev. M. M., St. Joseph's College, Collegeville — M

Easterday, Mr. Otho Dunreath, 224 N. Calvert St., Auburn — Ba, C
Easterday, Mr. Wayne G., Anderson High School, Anderson — Ba
Ebel, Miss Louise, Dept. of Biology, Valparaiso Univ., Valparaiso — Z
Eggerding, Mr. Milferd H., Geography Dept., Valparaiso Univ., Valparaiso — G

Evans, Miss Barbara Ann, 6674 North Pennsylvania, Indianapolis — Ba
Feltis, Miss Thora Jean, Route 18, Box 457, Indianapolis — C
Ferguson, Dr. James W., Butler University, Indianapolis — C
Fix, Mr. William Lloyd, P. O. Box 159, Princeton — Bo

Fuller, Prof. Forst D., Zoology Dept., DePauw Univ., Greencastle	Z
Fuller, Mr. Paul R., Psychology Dept., Indiana Univ., Bloomington	Ps
Fuller, Dr. Thomas C., Dept. of Botany, Hanover College, Hanover	Bo
Fuller, Mr. Wm. Richard, Butler University, Indianapolis	M

Gianotti, Mr. Eden J. J., Hanover College, Hanover	G
Gill, Mr. Charles W., Jr., Route 2, Wabash, c/o Loren Elliott	Z & C
Gourley, Miss Frances M., 905 Madison St., LaPorte	Bo, Z
Glaser, Mr. Robert, Psychology Dept., Indiana Univ., Bloomington	Ps
Gucker, Prof. Frank T., Jr., Chemistry Dept., Indiana Univ., Bloomington	C
Guennel, Mr. G. K., 4323 Kingsley Dr., Indianapolis	Bo
Guernsey, Mr. J. L., 18 Home Avenue, Terre Haute	G

Hallam, Mr. Kenneth Leslie, 5456 N. Capitol Ave., Indianapolis 8	Ph
Hamp, Miss Ruth Marie, Eli Lilly & Co., Indianapolis	Ba
Hare, Mr. Robert R., Jr., 3F Observatory Court, Greencastle	Ph
Hawkins, Prof. Harry Leslie, DePauw Univ., Greencastle	Ps
Hawley, Mr. Martin J., 7733 Gregier Avenue, Chicago 49, Illinois	Z
Hayes, Mr. John Clifford, Prefab. 86, Court E., W. State St., W. Lafayette	C
Hays, Mr. Robert L., 125 South Mill St., Westfield	Bo
Heckman, Rev., Norman L., St. Joseph's College, Collegeville	C
Hendrickson, Mr. Thomas M., 110½N. Lincoln St., Bloomington	G
Hickman, Mr. Cleveland P., Jr., 315 Greenwood Ave., Greencastle	Z
Hogan, Mr. Robert Eugene, 617 Second St., Columbus	G
Honeay, Mr. John S., Box 13, Whiteland	Bo
Hutchinson, Mr. Emory J., Route 1, Norman	Bo, Z
Hyer, Miss Ann, Audio-Visual Center, Indiana Univ., Bloomington	A

Jackson, Mr. Robert F., 522 Board of Trade Bldg., Indiana Flood Control Commission, Indianapolis	E
Johnson, Mr. Robert L., Dept. of Biology, Purdue University, W. Lafayette	Bo
Jump, Dr. John Austin, Biology Dept., Univ. of Notre Dame, Notre Dame	Bo

Kalter, Mr. Louis B., 717 North Ave., Dayton 6, Ohio	Z, G
Karling, Prof. John S., Biological Sciences Dept., Purdue Univ., Lafayette	B, Z
Keck, Mr. Bert Marion, Route 1, Paulding, Ohio	Bo
Kottlowski, Mr. Frank E., Dept. of Geology, Indiana Univ., Bloomington	Geo, G

Landerbaugh, Mr. E. E., Moores Hill High School, Moore Hill	Ph, C
Leininger, Mr. Richard K., Geology Div., Indiana Univ., Bloomington	C
McConnell, Mr. Rex, 2049 N. Meridian, Apt. 15, Indianapolis	C
McQueeney, Mr. Carl Ray, 4905 Matthews Ave., Indianapolis	Bo
Miller, Dr. George J., Geography Dept., Indiana Univ., Bloomington	Geo, G
Mitchell, Mr. Allen C., Physics Dept., Indiana Univ., Bloomington	Ph

Motley, Miss Jerry Anne, 1726 N. Alabama St., Indianapolis	Bo, Z
Mullins, Prof. A. G., Physics Dept., Indiana Central College, Indianapolis	Ph
Noyes, Mr. Bradford, 4087 N. Illinois St., Indianapolis	P
Oberbacher, Mr. Marion F., Stanley Coulter Hall, Purdue Univ., Lafayette	Bo
Omara, Miss Jean Anne, Mason Hall, DePauw Univ., Greencastle	Z
Osmun, Prof. John V., Entomology Dept., Purdue Univ., Lafayette	E
Peake, Dr. John Spencer, Chemistry Dept., Indiana Univ., Bloomington	C
Phillips, Mr. Travis J., 1419 Sweetser Ave., Evansville	Ph, C
Pitman, Mr. Joe A., Corydon	Z
Ramsay, Mr. Robert Skinner, Anderson College, Anderson	Ps
Rector, Miss Avis, 317 S. Grant, Bloomington	C
Rehm, Mr. Robert A., Phi Alpha House, DePauw Univ., Greencastle	Z
Reynolds, Miss Theo, Anderson College, Anderson	Ps
Roney, Mr. Claud H., Anderson High School, Anderson	M
Rothrock, Miss Dorothy, 1310 S. Kentucky Ave., Evansville 13	Bo
Rueve, Rev. Charles R., St. Joseph's College, Collegeville	M
Ryan, Mr. Paul J., 830 Drexel Ave., Fort Wayne	Z, Bo
Sanders, Mr. W. Leo, Senior High School, Anderson	Ps, Bo, Z
Sayler, Mr. Max W., New Market	M
Schaeffer, Prof. Harold F., Chemistry Dept., Valparaiso Univ., Valparaiso	C
Scheffe, Mr. Charles Earl, 609 Middle Drive, Woodruff Place, Indianapolis	Bo
Schmidt, Mr. Frederic Cowles, Chemistry Dept., Indiana Univ., Bloomington	C
Schwan, Mr. T. C., Valparaiso Univ., Valparaiso	C
Scofield, Mr. Robert E., Route 1, Box 105, Chesterton	Bo, Z
Scott, Miss Frances I., 1048 N. Beville Ave., Indianapolis	Bo
Seidel, Mr. Eugene M., Chemistry Dept., Indiana Univ., Bloomington	C
Shalucha, Dr. Barbara, Botany Dept., Indiana Univ., Bloomington	Bo
Shepherd, Mr. Ralph H., North Main St., Road, Bicknell	Z
Sherockman, Mr. Andrew Antolcik, Evansville College, Evansville	C
Sibert, Mr. George W., Wyandotte	G
Sister Mary Blanche, Central Catholic High School, Clinton & Lewis Sts., Fort Wayne	Ph
Sister Mary Rose Stockton, Marian College, Route 17, Box 56, Indianapolis 44	C
Starr, Dr. Donald D., Taylor Univ., Upland	C
Stephens, Miss Mary Alice, 474 South Street, Franklin	Ba
Stoneman, Mr. Elvyn A., Geography Dept., Indiana Univ., Bloomington	Geo & G
Totten, Dr. W. Fred, Wabash College, Crawfordsville	M
Tsareff, Mr. Thomas C., Jr., 1702 N. Lynhurst Drive, Indianapolis 24	C

Verplanck, Dr. William S., Psychology Dept., Indiana Univ., Bloomington	Ps
Von Wicklen, Dr. Frederick C., Indiana Central College, Indianapolis 3	C
Waldschmidt, Mr. Rudolph Charles, Psychology Dept., Valparaiso Univ., Valparaiso	Ps
Wantland, Mr. Kenneth W., 6036 Haverford Ave., Indianapolis	C
Warren, Mr. Kenneth J., Anderson High School, Anderson	Ps
Wayne, Mr. William John, R. F. D. No. 6, Bloomington	G
Williams, Dr. Eliot C., Jr., Zoology Dept., Wabash College, Crawfordsville	Z
Williams, Mr Marvin D., 328 Lawn Ave., West Lafayette	HS
Winkel, Mr. Theodore A., 607 N. East St., Madison	C
Wittig, Mr. Donald R., Butler Univ., Indianapolis	Ph
Yocom, Mr Wilbur J., Five Maples, Rosedale	Z

JUNIOR ACADEMIES

Centennial Science Club, Centennial School, 6th and Bronn Sts., Lafayette	GS
Science Club, Thomas Carr Howe High School, Indianapolis	Bo, Z, C, Ph

NECROLOGY

Will E. Edington, DePauw University

Emil Dietz

Rohrschach, Switzerland
February 2, 1864

Indianapolis, Indiana
September 27, 1947

Emil Dietz was a prominent Indianapolis business man who became deeply interested in science because of its philosophical implications. A prodigious reader, principally of philosophical and scientific books, he in time built up an excellent library and acquired a broad general knowledge of those fields.

Emil Dietz was born in Rohrschach, Switzerland, and was brought to Indianapolis by his parents while still a small child. He attended a German-English school until he reached the age of fourteen and then took a business course which completed his formal education. He began his business career as a bookkeeper for the Fred Dietz Company, manufacturers of wooden boxes and trucks. However, his active and practical mind asserted itself in seeking improvements in the company's manufactured products until he finally held eight patents on wooden packing box and factory truck construction, and he was finally promoted to the presidency of the company which position he held until 1910.

As one hobby he became much interested in astronomy and he possessed a four inch reflector telescope by means of which he observed and studied double stars. However, he was forced to give up his observational studies during the last ten years of his life because of blindness. He was also much interested in art and was a patron of a number of the older Indiana artists of whose work he possessed a fine collection which he had purchased when the artists were young and still struggling for recognition.

Mr. Dietz joined the Indiana Academy of Science in 1921 and while he did not present any papers he nevertheless maintained an interest in its work even in his last years. He is survived by two sons, Carl V. Dietz of Indianapolis, and Dr. Harry F. Dietz of Wilmington, Delaware, a Fellow and former Press Secretary of the Indiana Academy of Science

Charles Tobias Knipp

Napoleon, Ohio
August 13, 1869

Denton, Texas
July 6, 1948

With the passing of Charles T. Knipp the Academy lost another one of its most prominent members and one of its few remaining ties with the early days of the Academy and Indiana science, for Charles

T. Knipp became a member of the Academy in 1894 and maintained a steady and active interest in its work through all the intervening years by attending and presenting papers which appeared frequently in the Proceedings, the last appearing in 1936.

Charles Tobias Knipp was born on a farm in Henry, County, Ohio, near the town of Napoleon, on August 13, 1869. His father was much interested in farm machinery and had a shop in which young Knipp and his brother learned to handle tools and make things, a training that influenced him throughout the rest of his life. After he had completed the work offered in the township schools and the Napoleon high school and was ready for college, his father moved to Bloomington, Indiana, so that Charles and his brother and sister might attend Indiana University. Young Knipp entered Indiana University during the last year of the presidency of David Starr Jordan.

This was a golden age for science at Indiana University and also the age of opportunity for gifted young scientists. John M. Coulter succeeded Jordan as President in 1891 at the age of 39 and, with his coming, Arthur L. Foley was made Associate Professor of Physics at the age of 24 and Robert E. Lyons was similarly promoted to Associate Professor of Chemistry at the age of 21. In 1893 Joseph Swain, at the age of 36, succeeded Coulter as President, and David M. Mottier became Associate Professor of Botany at the age of 29.

It was in this scientific atmosphere that young Knipp received his physics training, his A.B. degree in 1894, and his A.M. degree in 1896. At the beginning of his senior year he was appointed instructor in physics. He retained this instructorship while he studied at Cornell University where the Ph.D. degree was conferred upon him in 1900. He returned to Indiana University as an Assistant Professor of Physics. In 1903 he accepted a similar position at the University of Illinois, where he attained the rank of Associate Professor of Physics in 1915, and Professor of Experimental Electricity in 1917. He retired in 1937 with the rank of Professor Emeritus. During his tenure at Illinois he went to Cambridge, England, and spent the year 1910-1911 working under J. J. Thomson in the Cavendish Laboratory. He returned there again to spend the year 1926-1927 in study. Following his retirement at Illinois Dr. Knipp accepted a visiting professorship of physics at Rollins College, Winter Park, Florida, and spent the years 1942-1945 there, after which he went to live with a daughter in Denton, Texas, where he passed away on July 6, 1948.

Charles T. Knipp was an outstanding scientist, being listed in Who's Who in America and starred in American Men of Science. He was a Fellow in the American Association for the Advancement of Science and was made an Emeritus Life Member in 1943. He held memberships in the American Physical Society, the American Institute of Electrical Engineers, the Optical Society of America, and the Society for the Promotion of Engineering Education. He was active in the Illinois Academy of Science, being its vice-president in 1920-1921 and its president the following year. He was also a member of Sigma Xi, Phi Beta Kappa, Tau Beta Pi, Eta Kappa Nu, and Epsilon Chi. He was also a member of the advisory subcommittee on physics for the Century of Progress Exposition in 1933.

He was the author of a large number of monographs and scientific articles. His first paper was published in 1895 in the Proceedings of the Indiana Academy of Science, and, during the years, eighteen of his papers appeared in the Proceedings. He was a very clever designer and demonstrator of apparatus and much of his success in the class room and laboratory was due to this skill. He was also an excellent glass blower. He was the inventor of a simple alpha-ray track apparatus, efficient mercury-vapor vacuum pumps, electrodeless electric discharge apparatus, and a cold cathode rectifier, and joint inventor of an alkali-vapor detector tube for use in radio. In his later years he frequently discussed or demonstrated his apparatus before the Physics Section of the Academy.

Dr. Knipp was not only an excellent scientist but he was also a good citizen who was much interested in church and civic affairs. He served as city councilman in Urbana, seat of the University of Illinois, for many years. He loved flowers and while in Urbana had a splendid rose garden. He also had a fine collection of Indian relics.

Despite the fact that he lived outside the State for most of his life, Dr. Knipp nevertheless retained a deep interest in Indiana and Indiana science, and it is fitting that the final services for him were held at Arcadia in the State where he received the inspiration and training that made his life the success it was.

GLADYS ETHELYN KNOTT

Colfax, Indiana — New Albany, Indiana
January 20, 1884 — February 26, 1947

Gladys Ethelyn Knott was one of that great group of high school science teachers who are striving to familiarize the youth of Indiana with their environment. She had become a member of the Academy of Science in 1929 and as a teacher of biological science in the Junior High School of New Albany she was instrumental in organizing the science club and affiliating it with the Junior Academy of Science in 1935 and serving as its sponsor until her death on February 26, 1947.

She was born in Colfax, Indiana, January 20, 1884, and after receiving her elementary education she continued her studies until she had secured the Master of Science degree from Purdue in 1911. She chose the career of teacher of biological science and taught in the schools of Illinois, Colorado, Florida and California, before she began her many years of service in the New Albany schools. She was an excellent and effective teacher and was highly respected and admired by her students and fellow workers.

Miss Knott was a quiet unassuming person but she possessed a charming personality. She had traveled quite extensively, especially in Mexico, Alaska and Norway, and these experiences quickened her teaching work. She was active in the American Association for University Women, the Daughters of the American Revolution, the Eastern Star and the White Shrine, and Trinity Methodist Church of New Albany. In her passing the State of Indiana loses one of its most faithful and devoted servants whose influence will continue in the lives of many of its better citizens.

MILTON MATTER

Marion, Indiana	Marion, Indiana
August 12, 1887	November 17, 1947

From its very beginning the Indiana Academy of Science has championed all movements for the conservation of the natural resources of the State, and the progress in conservation in the State during the past fifty years is largely due the efforts of such outstanding leaders in the Academy as Stanley Coulter and Richard Lieber. The need for conservation has appealed to many men whose interest in science has thereby been aroused, with the result that they have become leaders in this work. Such a man was Milton Matter who became a member of the State Conservation Commission in 1940 and served as Director of the State Department of Conservation during the years 1945 and 1946.

Milton Matter was born in Marion, Indiana, August 12, 1887, and his death occurred there on November 17, 1947. Except for relatively brief periods, most of his life was spent in Marion and he was one of that city's leading citizens. Following the completion of his public school education he entered Princeton University and was graduated in 1911. The following year he was appointed Director of John Herron Art Institute in Indianapolis. A year or two later he resigned to accept the professorship of Art History at Wells College, Aurora, New York. In 1914 he returned to Marion and became associated with the Marion State Bank of which he later became president. He was a veteran of World War I, having enlisted in the Air Corps in 1917, and later becoming a second lieutenant and commanding officer of a squadron.

Following his appointment to the State Conservation Commission in 1940 by Governor Shricker, both he and one of his sons, Milton Junior, joined the Indiana Academy of Science. Mr. Matter was also active in the Masonic Lodge and the American Legion, and he held memberships in several social and civic clubs in Marion.

While primarily not a scientist, he was nevertheless a conservationist and also interested in zoology, and to quote from an editorial that appeared in the Indianapolis Star, "Milton Matter was a versatile and all-around useful citizen and public servant."

PRESIDENTIAL ADDRESS

Mosses and Their Uses

Winona H. Welch, DePauw University

A botanist is frequently asked if bryophytes (mosses and liverworts) have any economic importance. The usual reply is that they are of scientific interest but have very little financial value. For some time this question and answer have been a source of interest to the writer. During the search for the uses of these plants it has been found that the term moss has been applied to many things incorrectly, that is to say, to objects which are not mosses, or has had unusual correct applications.

Due to the great looseness or flexibility of the English language, we find mosses not only in each of the divisions of the plant kingdom, Thallophyta, Bryophyta, where they are correctly classified, Pteridophyta, and Spermatophyta, but also in the animal and mineral kingdoms, and in various additional fields of knowledge.

In the thallophytes, numerous algae and lichens have been called mosses. Among examples of the former are Protococcus (Chlorophyceae), a green alga which sometimes grows on tree trunks, fence posts, telephone and telegraph poles, old buildings, etc. The layman often refers to the algae, Chlorophyceae, chiefly, which form the green scum on water as mosses. Recently the author was presented with a booklet of marine, red algae (Rhodophyceae), entitled, "California Sea Mosses," and within is this quotation, "Mosses bright, behold them, flowers of the sea."

Another group of plants in the Thallophyta to which the name moss is often applied is that of lichens, the plant bodies of which are composed of algae and fungi. Iceland moss is an erect lichen *(Cetraria islandica)*, having a foliaceous habit which suggests the appearance of a moss. Another lichen *(Cladonia rangiferina)* is often referred to as reindeer-moss, because it is almost the only source of winter food for the reindeer and caribou in high northern latitudes. The so-called old man's beard or gray moss, hanging from trees in northern swamps, is also a lichen *(Usnea)*. The terms tree moss, rock moss, and coral moss are often popularly applied to lichens in general. A lichen *(Parmelia perlata)* is used in dyeing and is popularly called canary moss. Cup moss is the name of various species of lichens, particularly of the genera Lecanora and Cladonia. *Usnea barbata* and various other pendulous tree lichens are popularly known as idle moss or beard moss.

The liverworts which compose with the mosses the division of the plant kingdom, Bryophyta, are sometimes described as the scale mosses, more particularly the Jungermanniaceae, the largest class in the Hepaticae. Indiscriminately, liverworts are often classed as mosses.

The plants in the genera Lycopodium and Selaginella in the Pteridophyta are commonly known as fir moss, clubfoot moss, or club moss. Although tree-moss is a name for various species of Lycopodium, it is particularly applicable to *L. dendroideum.* Snake moss refers to *L. clavatum.*

Passing on to the Spermatophyta one finds numerous flowering plants having in their common names the word moss. Some of the most interesting examples have been included in this discussion. In the rush family (Juncaceae), one finds the moss rush *(Juncus squarrosus).* The commonly known Spanish Moss *(Tillandsia usneoides),* sometimes called long moss, black moss, crape moss, wool crepe, barba Hispanica, New Orleans moss, and Florida moss, in southern United States, is an epiphytic member of the Pineapple family *(Bromeliaceae).* According to Aldrich, DeBlieux, and Kniffen[1], the early Louisiana settlers called this plant Barbe Espagnol or Spanish beard, and the term Spanish moss has only recently come into general use. Flowering moss *(Pyxidanthera barbulata)* is a creeping, evergreen, flowering plant of the New Jersey pine-barrens. In the Phlox family (Polemoniaceae) there are the moss pinks *(Phlox subulata)* which grow on rocky hills in central United States and are often cultivated for their beautiful flowers. The moss rose *(Rosa centifolia muscosa)* bears an abundance of glandular hairs on the peduncle and calyx, which resembles a mosslike growth and thus suggests both the common and varietal names. In Europe, the common name for the fruit of the small cranberry *(Vaccinium Oxycoccus)* is mossberry as it grows only in peat bogs, usually among the mats of Sphagnum, a moss. A catchfly *(Silene acaulis)* which grows on the highest mountains of Europe and America and within the Arctic Circle appears mosslike and bears the common name of moss campion, because of its dwarf tufted moss-like habit. Moss-locust is the common name for the hispid shrub, *Robinia hispida.* The fruit of the bur oak *(Quercus macrocarpa)* has a very pubescent involucre, giving rise to the common name of mossy-cup oak. Moss wood has reference to tree trunks and stumps which are frequently found in peat bogs. Moss-oak is oak-wood preserved in a black state in peat bogs.

In zoology, one recognizes the names of bryozoan, moss-animal, moss-coral, and moss-polyp, given to small animals which have a mossy appearance. The common name of one of the American marine fish in the Herring family is mossbanker or mossbunker *(Brevoortia tyrannus).* Mossback is also applied to fish. Anglers attribute this name to large and old fish, especially bass, in allusion to a growth of algae. The large mouthed black-bass *(Micropterus salmoides),* which occurs in Indiana, bears the common name of moss-bass. The moss-back turtle is probably coated with algae rather than mosses. In ornithology, there is listed the moss-cheeper of Scotland for the titlark or reed bunting *(Emberiza schoeniclus),* the moss-duck of England for the mallard, the moss owl for the short-eared owl of England and Scotland, the moss hammer for the European bittern of England, and the mosshead for the hooded merganser *(Lophodytes cucullatus)* of South Carolina. In entomology, one of the bumble-bees bears the common name of moss-carder and the scientific name, *Bombus muscorum*, the specific epithet originating from *muscus*, the Latin word for moss.

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[1] Aldrich, C. C., M. W. DeBlieux, and F. B. Kniffen, The Spanish Moss Industry of Louisiana. Economic Geography **19**, 347-357. (1943).

In geology there is the moss agate or Mocha stone which is a variety of agate containing brown, black, or green matter in filamentous or dendritic forms suggestive of vegetative growth, especially that of a moss. When gold occurs in dendritic forms it is called moss gold. If silver appears in filiform or dendritic shapes, it is known as moss silver. If zinc forms thin, brittle flakes when poured slowly into water, it is called granulated or mossy zinc.

In home economics, in dietetics, there are directions for preparing blanc mange. This food is made from a sea weed or red alga (Rhodophyceae), botanically known as *Chondrus crispus* and commercially recognized as Irish moss because of its abundance along the coasts of Ireland and Great Britain. (The rake used in gathering the Irish moss is known as a moss-rake.) Ceylon moss and Jaffna moss are common names for a seaweed or red alga *(Gracilaria lichenoides)* of Ceylon and the Indian archipelago, which is similar to Irish moss and is used for food in great quantities by the inhabitants of the above-mentioned places and by the Chinese. Corsican moss is an esculent alga *(Plocaria Helminthochorton)*. And, perhaps not irrelavent to the field of home economics is moss-starch which is a kind of starch obtained from Iceland moss and other lichens. In the New York Times, March 28, 1937, a new item for a breakfast menu was introduced under this interesting title, "Alaska 'Sourdoughs' add moss to menus." The new breakfast dish recommended is "mossolyte" croquettes. The prospectors found while working in Yukon Territory that their dogs thrived on the moss, so tried it for their own diet. Since in the far North, moss usually refers to lichens, it may be assumed that these croquettes were not made of true moss.

History also has included in its pages these small plants in records of the marauders which infested the border country between England and Scotland. These bandits were called moss-troopers because the country which they inhabited was mossy or boggy. During the Civil War in the United States the name of mossback was applied in the southern states to one who avoided conscription by hiding himself. In political slang we also have the mossback, a title referring to a partisan with such antiquated notions and extremely conservative opinions that he is compared with a stone or an old tree covered with moss.

In literature one finds a title by Nathaniel Hawthorne of "Mosses from an Old Manse," which is a collection of short stories. The idle moss of Shakespeare's books is a pendulous lichen which grows on trees and is botanically known as *Usnea barbata*. The references to mosses in stories and poems concerning nature are too numerous to cite, but one quotation from a poem, "Little Sermon of Peace," by Willis

Boyd Allen, contains the following quotation with reference to the third Beatitude which seems so appropriate to these plants and their habitats that it has been included. (It may be assumed that the poet has reference to true mosses.)

"Humblest creatures of the wood
To your peaceful brotherhood
Sweet the promise that was given
Like the dew from heaven:
  'Blessed are the meek
  They shall inherit the earth';
Thus are the words fulfilled:
Over all the earth
Mosses find a home secure."

The proverb, "A rolling stone gathers no moss," is familiar to all. It may be assumed that this reference is to stones in a swiftly flowing stream. If this assumption is correct, the plants under consideration were probably algae as true mosses usually grow on stones not in motion. Or, if we conjecture a stone rolling down a bare and exposed slope, the plants to which reference was made may be lichens.

In Webster's dictionary one finds moss used as a transitive verb, so that it is correct to speak of mossing. Not strictly in the sense that moss collectors sometimes jokingly use it when they say that they are going mossing, but meaning to cover or to roof with moss or to overgrow with moss, as illustrated by the following quotation from Shakespeare, "An oak whose boughs were mossed with age." Also, in the dictionary is the descriptive adjective, moss-grown, with the meaning of overgrown with moss, and the noun, mossiness, which refers to the state of being mossy. In addition, a mosser is one who collects mosses or works with them, and a mossery is a place where mosses are grown.

In art, two names of colors are old moss green and moss gray. In music, there are the words so often sung, "The old oaken bucket, the moss-covered bucket that hung in the well."

Even a list of beverages includes the mosses although misnomers.

The moss-alcohol of Norway, Sweden, and Russia is made from reindeer moss and Iceland moss, both of which are lichens. Irish-moss ale which is assumed to be potent in the treatment of some diseases has for one of its important ingredients the Irish moss, an alga.

Although this list of the unusual or incorrect applications is incomplete, it seems sufficiently long to now stress the importance to mankind of liverworts and true mosses. It is evident that plants which have permeated such numerous and varied areas of thought have attracted the attention of man for many years. It seems that a group of plants as large as the Bryophyta, approximately 8,800 species in the Hepaticae and 14,000 in the Musci, may have some members of both scientific and economic value, the common opinion quite to the contrary with regard to the latter, especially. Peat mosses (Sphagnales) and true mosses

(Bryales) are the largest orders of mosses. Thus, they are the chief contributors of the items of importance to mankind.

The leaves of Sphagnum have a very peculiar structure and due to this peculiarity Sphagnum has many uses which cannot be attributed to other mosses. The thickness of the leaves consists of one layer of cells. There are two distinct kinds of cells in Sphagnum leaves. One type consists of large, colorless, empty cells open to the exterior by a pore. These empty cells make possible the absorbent and retaining qualities of this moss. The porous cells are surrounded by smaller, chlorophyll-containing cells.

Sphagnum bogs consist of layers of peat varying from a few feet deep to unknown depths. Animals and persons have been found in bogs, remarkably well preserved by the antiseptic properties of the peat. According to Dana, in peat bogs of Europe, in recent times, there have been discovered horses and knights in armor, from the days of the Wars of the Roses, in a very good state of preservation, and bodies of humans clothed in haircloth of a prehistoric period.

Peat moss (Sphagnum) is most efficient of all mosses in conserving water. Much sphagnum from swamps is of no commercial value because it is brittle and is of the single stem type. The plants which are of economic importance grow in mats, shaped like sponges, and can be cut out of bogs in masses. The top portion of the mass is of better quality than that beneath it, as it will absorb about 25 times its own weight in moisture in comparison with the moss in the next layer below which will contain 16-20 times its weight in water. A bale of dry sphagnum weighing only 20 pounds has been found to weigh approximately 500 pounds when soaked with water.

The peat which underlies the moss is excellent fuel material, and while burning, produces a pleasant odor. It is cut into blocks or slabs and dried. Some kinds are reported to burn longer than hard wood or coal. It has been estimated that 1⅘ tons of peat is equivalent to 1 ton of coal for heating purposes. Thus approximately one-half the heating power of good coal and more than two times the heat of wood. Peat is built by Sphagnum plants at the approximate rate of 1 foot in 100 years. Ground peat is pressed into small cubes a few inches square and sold for kindling material. A small quantity placed on wood and lighted will burn easily and will hold heat long enough to ignite hard wood.

Sphagnum, mixed with bone dust, is frequently employed by flower gardeners in the greenhouse as a mulch on top of the soil in the flower pots in which plants are being started for later transplanting in the garden. It shields the earth from the sun and stimulates root growth toward the surface.

Sphagnum is of considerable commercial use in florist and nursery trade where it is used for keeping living plants fresh during shipment. It is excellent packing material for the shipment of perishable articles to distant markets, such as fruits, vegetables, tubers, and bulbs, because it is relatively sterile, holds moisture for a long period, and acts as an insulator against heat and cold during shipment. Greenhouse operators and nurserymen have found wet peat moss useful in packing roots of plants for transportation and market. Live fish have been shipped long distances packed in sphagnum.

A form of granulated or pulversized peat moss, sometimes called peat-humus and consisting of 92% organic matter, is marketed in bags and is used by gardeners as a moisture retaining humus. It may be incorporated with soil or spread over the surface of soil as a mulch. This moss keeps the earth loose, prevents a hard top crust, discourages weed growth, and prevents the soil from cracking. Sphagnums are largely used in the propagation and cultivation of rare orchids, because of their efficiency in retaining moisture.

Peat moss is employed in forming a top-dressing for golf-course greens, and for providing an absorbent layer on poultry house floors in winter months. Dachnowski-Stokes[2] has included additional uses of Sphagnum peat: employment of it as a sanitary bedding for horses, cattle, and other livestock, with the accompanying advantages that it decays relatively slowly, absorbs and retains liquid manure more completely than do other kinds of litter, decreases losses in available nitrogen, prevents odors, checks insect pests in dairy barns, horse stables, poultry houses, and fur-bearing animal sheds; an absorbent in places lacking sewer systems; and in finely shredded condition, as a medium for germinating seeds, rooting cuttings, transplanting and growing evergreens and heaths, and as a mulch for protecting plants and soil against the effects of alternate freezing and thawing, and for reducing the number of weeds.

Warden[3] reports that sphagnum peat, valued at more than $1,200,000 is imported to the United States annually, for use of gardeners and poultrymen, and that wholesale, the peat moss brings $20 per ton.

By rapid and unlimited growth, dense mats of Sphagnum gradually fill in hollows, bogs, ponds, and small lakes. Vegetable débris is washed and blown in until vast beds of peat are formed. The mats also aid in the formation of soil which is capable of supporting the growth of higher types of vegetation, thus playing an important role in plant succession in bogs. Sphagnum mats are often large constituents of floating islands upon which trees will eventually grow. Peat mosses helped to build much of the muck land that produces our celery and other garden truck. Indirectly blueberries and cranberries are dependent upon the Sphagnum or peat moss bogs because blueberry and cranberry bogs are basically peat bogs.

Peat charcoal has been used for smelting iron and for working and tempering certain kinds of steel. Tests have proven Sphagnum to be an efficient insulating material, and peat dust to be a very effective deodorizer.

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[2] A. P. Dachnowski-Stokes, Moss Peat, its Uses and Distribution in the United States. U. S. Dept. Ag., Washington, D. C., Circular No. 167, pp. 1-11. 1931.

[3] Carl Warden, Waste Land Yields Treasure in Peat Moss, Center Barnstead, New Hampshire. Pop. Sci. Mon. **136**, 112-114. (1940).

According to Newsweek, November 22, 1948, page 53, Russian mining engineers are compressing peat moss into briquettes and dipping these into liquid oxygen, in the preparation of an explosive which can be used like dynamite, with the advantages of being non hazardous in storage and transit, as well as less costly.

Laplanders and Icelanders have used sphagnums for cradle linings. The American Indians used it for diaper material. In cold countries these mosses have served as warm linings or stuffings for the loose deerskin boots which the reindeer drivers wear.

Some of the species with the greatest absorbing power have been found to be very satisfactory dressings for wounds, because it not only absorbs puss and drainage from wounds but also has antiseptic properties. History does not record how long Sphagnum has been used by the country people as a dressing for boils and discharging wounds. The story of the discovery of its value by a surgeon in the seventies of the nineteenth century is fully recorded by Heald in the Scientific American[4]. "A laborer in a peat moor in northern Germany was seriously wounded in the forearm. Not having surgical dressings at hand his companions applied 'first aid' in the form of 'peat moss' picked up from the ground. Surgical help could not be obtained for ten days. Meantime the dressings were not changed. When finally the surgeon undid the wound, he was astonished to find it practically healed. He communicated his findings to his fellow physicians, and further investigation showed the great superiority of Sphagnum moss as a dressing for discharging wounds. It then became a standard dressing in hospital and private practice. In the Russo-Japanese War, the Japanese physicians used it extensively as a first-aid dressing at the front, and sometimes these dressings were not removed for as much as ten days, and yet the wounds were generally found to be in much better condition than similar wounds dressed with cotton."

Porter[5] states that sphagnum pads absorb liquids much more rapidly than cotton, approximately three times as fast, in much greater amounts, cotton absorbing five to six times its weight of water and sphagnum sixteen to twenty-two times, retains the liquids much better and therefor fresh dressings being needed less frequently, distribute absorbed liquids more uniformly throughout their mass, are cooler, softer, and less irritating, and can be produced at less expense and more speedily in times of emergency.

Only species with dense foliage and closely set branches have the qualifications to give the advantages of Sphagnum such as high absorption capacity, sponge-like matting, porosity, softness, elasticity, lightness, and strong acid reaction. The porosity of the large but microscopic empty cells of the leaves enable Sphagnum to take up liquids much more rapidly and in amounts several times greater than the same amount of absorbent cotton.

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[4] G. H. Heald, Sphagnum Moss. Sci. Am. Supp. **87**, 48. (1919).

[5] J. B. Porter, Sphagnum Surgical Dressings. Int. J. Surg. **30**, 129-135. Figs. **1-8**. (1917).

During World War I, a few species of Sphagnum were used in large quantities by the Allied Armies as a substitute for absorbent cotton in surgical dressings. Long ago the country people of Europe used Sphagnum and Sphagnum peat as sanitary bedding and in treatment of boils and discharging wounds of man and domestic animals. The Canadian Red Cross made over 200,000 moss dressings per month during the summer of 1918 and near the end of the war the British used approximately 1,000,000 moss dressings per month. The American Red Cross officially adopted Sphagnum moss as a standard dressing material in 1918, developed a monthly output of over 20,000 pads for American military hospitals, and prepared half a million Sphagnum dressings for the Italian Army. The species having the greatest efficiency in surgical dressings are *Sphagnum magellanicum*, *S. papillosum*, *S. imbricatum*, and *S. palustre*.[6] Sphagnum is recommended for hospital mattresses and sanitary appliances because of the absorbent and deodorizing properties, but it probably will not be used extensively because of the superior substances now in general use.

Large quantities of moss peat are produced in Europe at comparatively low cost and shipped over seas. Its consumption in our country is continually growing. In the United States there are three areas which are promising in supplying desirable moss peat, Maine, northern part of Wisconsin and Minnesota, and along the Pacific coast in northern Washington and Alaska. According to the Scientific American **166**: 198. 1942, "Alaska has a virtually untouched 'Klondike' in its 110 million acres of peat muskegs, if anyone can develop satisfactory and inexpensive ways of packing and transporting the peat."

Let us now consider the liverworts and the true mosses. The origin of the word, liverwort, was from the resemblance of some of the thallose plants to the lobes of the liver. The "doctrine of signatures" claims that these plants had valuable medicinal properties for treating liver ailments.

Liverworts and mosses are small plants, the former thallose or leafy in habit and the latter, leafy. The bryophytes lack true roots, stems, leaves, and vascular system found in the Pteridophyta and Spermatophyta. The majority of leaves are one cell in thickness. The Bryophyta are spore-bearing plants, producing the spores in the capsule of the sporophyte which is completely or almost entirely parasitic upon the gametophyte. Because of the dependence of the plants upon water for fertilization, and the inefficiency of most of the species for conserving moisture, they are usually found in shaded habitats of high humidity and low evaporation. Liverworts and mosses grow on soil, rocks, wood, and in water. Numerous species are epiphytic on the stems and leaves of other plants. Occasionally bryophytes are found in dry and sunny habitats.

The Bryophyta are important from a purely scientific view point as their morphology aids in tracing theories of development of the plant kingdom from the Thallophyta to the Pteridophyta.

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[6] A. P. Dachnowski-Stokes, Sphagnum Moss for Use in Surgical Dressings. Sci. Mon. **55**, 291-292. (1942).

Also of scientific interest are the collections of mosses and liverworts from various parts of the world because they have been of considerable significance in the study of plant migration and in the determination of the relationship of floras. W. C. Steere[7] has indicated that for the purpose the lack of important economic uses has been very advantageous for these studies because the bryophytes have not been taken from their native habitats as the inhabitants have moved from place to place.

People who collect and study mosses and liverworts do so for the sake of scientific contributions to knowledge rather than for financial or commercial profit.

The Hepaticae share with the Musci in the ability to form soil, prevent erosion, increase humus, and absorb moisture quickly through the chlorophyll-bearing parts. **Conocephalum conicum** at one time was thought to have some medicinal properties. Various species of the liverworts are attractive plants for terraria.

From an economic standpoint, it seems that their contributions to the formation of soil from bare rock surfaces and to the preparation of habitats favorable for the germination of the seeds of the herbs, shrubs, and trees which are to be their successors, compose the greatest value of the true mosses to mankind. Without soil to support the growth of herbaceous and woody plants, the sources of food, clothing, and shelter, directly or indirectly, would be greatly limited. The great economic importance of a moss covering on rock or soil is evident upon the observation of the growth of the seedlings of plants more highly evolved, growing in the mat of mosses, all of which leads to the eventual tree associations. Economically and in nature, mosses are more significant than liverworts, and in the Musci, it seems that the Sphagnales are of greater direct importance, and the Bryales of more general and indirect value.

During the summer of 1932, while a student in the laboratory of Dr. A. J. Grout, the common question, "Of what use are mosses?", was discussed. Since that date notes have been assembled regarding their importance. Dr. Grout's reply, published in the Scientific Month 38: 270. 1934, is aptly and characteristically stated, "We can neither eat nor wear them, but certain kinds have been used to stuff beds on which to sleep."

Certainly no one can be unaware of the esthetic value of the mosses and liverworts. A few moments spent in imagining the faces of canyons, rocky slopes, the sides of a spring, the forest floor, tree trunks or logs in a dense woods, stones along the brooks, and even the shaded roofs of old buildings, without bryophytes, quickly bring to our attention the beauty produced by these small and frequently unnoticed plants, which are available at all seasons of the year. The majority of the principle families are world-wide in distribution, and by carefully searching it is possible to find representatives in almost any locality.

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[7] W. C. Steer, The Collecting of Mosses and Liverworts. Instructions to Naturalists in the Armed Forces for Botanical Field Work, No. 3, pp. 1-13. 1944. Ann Arbor.

Bryophytes are the lowest, in an evolutionary way, of the existing terrestrial, chlorophyll-bearing plants, and are composed of tissues so delicate that those of the past ages have left few recognizable traces of their geological history. The study of bryophytes entails minute observation, but shows them to be of great scientific interest, because they present a special type of life history and in some groups give definite evidence of evolutionary trends in spite of the absence of reliable evidence from fossil remains of their geological history.

Recalling the "doctrine of signatures" which claimed that the medicinal uses of plants were indicated by their shape and structure, a decoction of the Hair-cap mosses was formerly much used to aid in the growth of hair.

Dicranum scoparium is often used by florists to form banks of green in show windows. Dr. T. C. Frye of the University of Washington has informed the author of the use of *Rhytidiadelphous triquetrus*, *R. loreus*, and *Hylocomium splendens* as a "green carpet" for the Rhododendron, rockgarden, and general floral shows in Seattle. These mosses grow on the floor of the Douglas Fir forests and are brought to the city for the floral exhibits in five-ton loads each year.

Conard[8] reports that some of the giant west coast mosses are serving as replacements for excelsior or shredded paper in packing crockery.

Schistostega pennata is an exceedingly interesting plant. It grows on soil and stone of caves, dark holes, and other habitats having very little light. This bryophyte is called the Luminous Moss because from the persistent protonema there comes a golden-green glow by reflected light on the luminous subspherical cells at the ends of the filaments. Dr. Grout states in Moss Flora of North America 2: 103. 1940, "This beautiful plant is probably the reality upon which is based the fairy tales of goblin gold."

Young moss capsules full of spores are rich in protoplasm and serve as food for mice and insects both in field and herbarium. However, mosses rarely serve as hosts to parasitic fungi or as food for animals.

In Europe during the past, in the process of sinking a shaft in rock, a moss-box has been employed. In this procedure dry moss was used for packing to aid in making tight joints. Concrete is now used instead of the moss.

One of the Christmas traditions in Switzerland is the custom in the homes of the mountainous regions of making a manger of moss and placing it at the hearth for the spirit of the Christ Child.

In Britain, according to Bagnall,[9] *Hypnum triquetrum*, because of its extreme elasticity and lightness, is used for packing brittle wares, and dyed an intense green for sale in shops for decorative purposes; *H. purum* serves anglers for a medium of scouring worms; *H. tamariscinum* is used for shipping leeches; and in northern England, *Polytrichum commune* is used for mattresses and regarded as superior to straw, is woven into door mats, and its stems are used for making brushes for dusting beds, curtains, carpets, hangings, etc.

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[8] H. S. Conard, How to know the Mosses. P. 10. 1944. Iowa.

[9] J. E. Bagnall, Handbook of Mosses. P. 85. 1886. British.

The Laplanders use *Polytrichum commune* as bed and bedding. They select a patch of male plants, cut an area large enough for a bed or bolster, and separate this layer of entangled plants from the soil. This mossy cushion is said to be very soft and elastic, not to grow hard by pressure, and to be quickly restored to original elasticity by moisture if it becomes too dry and compressed. A similar portion serves as a coverlet. Linnaeus recorded that he had often used the Hair-cap moss in this way with much satisfaction, and added that the Laplanders tie this bed and coverlet in a roll, when necessary, and carry it with them from place to place. They have also used it for stuffing pillows and beds. At one time *P. commune*, being slightly astringent, was used as a medicine in Sweden. In Germany it is considered as a sudorific. This moss has been reported as serving as stuffing for cheap pillows and upholstery in the United States.

In parts of Sweden, *Fontinalis antipyretica* has been used for filling spaces between the chimneys and the walls, and thus, by excluding air, preventing fire. This custom was the basis of the specific epithet, *antipyretica*, and the erroneous idea that this moss is incombustible.

According to Campbell,[10] Spruce, when collecting plants in South America, found the bryophyte vegetation so luxuriant that when the forest was very wet and the mosses and liverworts were soaked with water, that their weight was sufficient to break off the branches of the trees upon which they were growing.

Even without practical importance, it is of interest to observe *Fontinalis biformis*, one of the aquatic mosses in Indiana, which produces two kinds of leaves of distinct appearance during the year. The flaccid, plane leaves develop in the spring and are replaced during the summer with firm, concave, and narrower blades. The former are commonly described as the vernal leaves and the latter as the aestival.

Moss has been used in the names of places of sufficient importance to be cited in encyclopedias. The following have been noted: Moss, Norway, Moss, district in West Africa, Mossvale, New South Wales, Moss, Mississippi, Moss, Tennessee, Moss Beach, California, Mossybrook, Washington, Mossyhead, Florida, Mosspoint, Mississippi, and Mossville in Arkansas, Illinois, Kentucky, and Louisiana.

Some scientists have found the mosses and liverworts to be sources of interesting and profitable experiments in photography of minute and microscopic structures for projection slides.

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[10] D. H. Campbell, An Outline of Plant Geography. P. 284. 1926. New York.

Proceeding to contributions more scientific, some bryophytes serve as plant indicators as do some of the spermatophytes. Fires of recent occurrence may be indicated by an abundant growth of Marchantia, Funaria, and Bryum. *Fissidens minutulus* and *F. incurvus exiguus* have been found to be indicators of sandstone substratum and *Grimmia apocarpa, Desmatodon Porteri,* and *Bryum argenteum* of alkaline substratum, and *Dicranum scoparium* and *Leucobryum glaucum* of one somewhat acid.

When it rains, mosses absorb water very rapidly through the thin-walled cells of their leaves, and as the atmosphere becomes dry the leaves close tightly to retain the moisture. The arrangement of leaves similar to the shingles of a roof, also aids in the retention of water. According to Grout,[11] "One of the most important economic services of mosses is due to this power to absorb and retain moisture. Forests are given credit for retaining moisture, preventing floods and keeping up a steady flow of water in streams, but a very large part of the water-conserving power of forests is due to the mosses which grow in the shade of the trees."

Bryophytes colonize bare rock, following the lichens. They also cover areas of soil made bare by erosion, fires, and landslides, and, when firmly established, hold the particles of earth until larger plants are able to establish themselves.

In beds of mountain streams the stones and soil are usually covered with mosses when the water is low. These plants accumulate soil which is washed down from above, continuing to collect a fresh layer of mud each season at the base of the stems, which in turn continue to elongate. Moss-covered stones in brooks are frequently found stopping quantities of sand and gravel which otherwise would have been carried away by the water.

Moss portonema is one of the first vegetative growths on soil made bare by man or nature. This forms an attached cover over the loose soil which prevents the water of spring floods and summer showers from washing away the soil. Bryophytes, especially the mosses, are of some degree of importance in breaking the force of rain upon the substratum and in the prevention of soil erosion. Those which are terrestrial anchor the particles of soil by means of their rhizoids.

The plants which are dominant in our vegetation receive their water supply through roots. Bryophytes absorb water through rhizoids and through their chlorophyll-bearing organs whenever they are moistened by rain or dew; especially is this true of the prostrate forms. In erect mosses with stems more or less solitary, the rhizoid absorption probably exceeds that of the leaves except when the plants are wet with dew or rain. Cushion plants such as *Leucobryum glaucum, Bartramia pomiformis,* and *Dicranum scoparium* absorb water readily through the aerial parts.

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[11] A. J. Grout, Mosses. Sci. Mon. 38, 270-273. 1934.

Mosses are able to establish themselves and to thrive in regions unfavorable to more advanced plant bodies because of their capacity to dry up and then to revive in a fresh supply of moisture, because of their hardiness, and because of their ability to assimilate, apparently at very low temperatures, more quickly than the seed plants. One may be convinced, also, of the immense value of a moss covering in the conservation of water supply, by considering the amount of moisture retained by this mat of plants on rocky slopes and on the sides of canyons.

The bryophytes are considered as colonizers because they can gain a foothold on bare rock, soil, and wood, where more highly developed plants, as to evolutionary standards, have failed, and thus, over a period of time, prepare a suitable substratum for those higher forms of plant life.

Bare areas on moist ditch banks along roadsides occasionally are covered with a mat of the green felt-like persistent protonema of Poponatum, especially if the soil has been recently disturbed. The leafy gametophytes occur singly and scattered. The protonema not only supplies a large part of the nutrition and retains water for the plants, but also holds the soil in place, preventing errosion to a great extent.

In the stages of plant succession from a primary bare area of rock to climax vegetation, the mosses follow the first and second stages of crustose and foliose lichens, respectively, and precede the herbs which are succeeded by shrubs and trees. Each in turn has possession of a habitat, produces profound influences upon it, and makes conditions favorable for the next community by increase in humus and accumulation of soil, and by the production of a more mesophytic habitat.

Weaver and Clements[12] cite a moss xerosere consisting of *Grimmia, Polytrichum juniperinum, P. piliferum, P. commune,* and *Tortula.* These xerophytic mosses follow the lichens as soon as sufficient amounts of soil have accumulated in the minute crevices and depressions in the rock. These mosses can endure desiccation. The plants continue growth above and die below, and rapidly accumulate soil between the erect stems, thus continually adding to the substratum which was begun by the pioneer lichens. The depth of soil under a cushion-like moss has been found to be one inch or more, according to Weaver and Clements.

Ceratodon purpureus has been found by Gates[13] to be the pioneer in plant succession on a bare area of sand in Michigan and *Polytrichum juniperinum* to be second in the sere. The Hair-cap mosses, *Polytrichum piliferum* and *P. juniperinum* are frequently successful pioneers on sandy soils because they readily establish themselves by dense growths of rhizoids, and when covered by blown sand quickly produce long branched etiolated shoots.

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[12] J. E. Weaver and F. E. Clements, Ecology. P. 67. 1929. New York

[13] F. C. Gates, Moss in the Revegetation of an Area in northern Michigan. Bryologist **49**, 66-71. (1946).

In the succession of mosses on Lake Michigan dunes, Taylor[14] found the pioneer mosses to be xerophytes, such as *Ceratodon purpureus*, *Bryum caespiticium*, and *B. ventricosum*, in scattered tufts or cushions. She also found thick and continuous mats of mesophytic mosses. *Thuidium delicatulum*, *Hylocomium triquetrum*, and *Calliergon Schreberi*, frequently excluding all seed plants, as well as many species of mosses, and thus exerting a controlling influence upon plant succession. In the Chicago region, Taylor found *Bryum argenteum*, *Grimmia apocarpa*, and *Ceratodon purpureus* as successors to the crustose lichens in rock succession.

Glenn and Welch[15] found in studying the stages of plant succession in Monroe County, Indiana, that *Fissidens minutulus* and *F. incurvus exiguus* are pioneers on bare sandstone areas and that *Grimmia apocarpa* followed the lichens on exposed limestone.

Leach[16] reports that in England, *Polytrichum piliferum*, *P. juniperinum*, and *Ceratodon purpureus* are pioneers on various types of soil, including heath-land where Calluna has been burned. that *P. piliferum* and *P. alpinum* are pioneer species on certain kinds of rock detritus, that *P. piliferum* is a pioneer on noncalcareous soils, and that above altitudes of 600 meters, *P. alpinum* is the first moss to enter on rock detritus. In these higher altitudes *Rhacomitrium lanuginosum* forms a surface carpet against weather action but its rhizoids are not efficient to bind the soil and this layer is frequently destroyed, so *Polytrichum alpinum* serves as the pioneer and stabilizer.

Warming[17] gives special attention to the covering of moss because it differs from any other vegetative covering in its effect on the amount of water in the soil, the effect varying with the species. Species of Hypnum and of other genera in the Hypnaceae produce dense cushions, 5-6 centimeters in thickness, which lie loose on the soil. The felt of rhizoids and the protonemata of plants of Polytrichum and Dicranum permeate the soil and promote the formation of raw humus. In Arctic and Antarctic areas, Warming explains, the dense, soft carpet of moss merges into either the Polytrichum moss-tundra or the Sphagnum bog or tundra. Species of Polytrichum and Dicranum form dense, firm tufts, and intermingled with them are species of Hylocomium, Hypnum, and Rhacomitrium and liverworts belonging to the genus Jungermannia. It has been found that a carpet of moss does not desiccate the soil because the plants obtain little or no moisture from the soil by absorption and conduction, and at the same time the mosses prevent by their presence the drying out of the soil.

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[14] Aravilla M. Taylor, Ecological Succession of Mosses. Bot. Gaz. **69**, 449-491. (1920).

[15] Gail G. Glenn and Winona H. Welch, Ecological Relationships of the most common Mosses in a certain Vicinity near Bloomington, Indiana. Proc. Ind. Acad. Sci. **40**, 87-101 (1931).

[16] W. Leach, On the Importance of some Mosses as Pioneers on Unstable Soils. J. Ecology **19**, 98-102. (1931).

[17] Eug. Warming, Oecology of Plants. pp. 76, 198 (1909). Oxford.

According to Braun-Blanquet,[18] *Rhacomitrium hypnoides* is an important constituent of the homogeneous moss and lichen tundra in Spitzbergen; in the moss seres in cold moist regions such as parts of Siberia, Lapland, Faroe Islands, and Spitzbergen, the climax vegetation is Rhacomitrium heath; and in Auvergne, France, there is a notable lateral advance of the *R. lanuginosum* association upon basalt rubble.

The true mosses not only contribute to the formation of soil and the increase of humus, but also to the building of rocklike substances such as tufa and travertine. Taylor has found *Brachythecium rivulare* to be a prominent tufa former. "The chemical substances (iron compounds) in the water penetrate the plant tissues which, as they grow old, resist decay and form a porous rocklike mass."

Emig,[19] in the study of travertine formation in the Arbuckle Mts. of Oklahoma, found two species of mosses, *Didymodon tophaceus* and *Philonotis calcare,* taking prominent part in the depositing of calcium carbonate, and *Brachythecium rivulare* in the depositing of iron ore. The deposits of soft limestone and travertine increase the height and width of waterfalls. Emig explains, "In spite of successive erosions, travertine continues to grow by aid of algae and mosses. The mosses act only indirectly in the precipitation of calcium carbonate, principally by supplying a larger absorptive and adsorptive surface for the evaporation of the calcareous water."

Cowles found *Cratoneuron filicinum* active in tufa formation at Turkey Run, Indiana.

Taylor[20] has found moss having a part in the formation of bog iron ore. "At Otis, Indiana, and New Lenox, Illinois, are numerous springs, water of which is highly impregnated with iron compounds. In the outlet of such a spring is frequently found large quantities of *Brachythecium rivulare* B. and S. As the iron compounds penetrate the moss tissue, a hard porous tufa is formed which becomes a part of the accumulation of bog iron ore about these springs."

Taylor continues regarding mosses contributing to the formation of floating islands in northern Indiana along Lake Michigan. "Floating islands, which seem to have had their origin in a surface mat, formed over the water as in the case of quaking bogs. Portions of mats have here broken loose from shore, and now form small islands floating without attachment to bottom or margin. One of the chief agents in formation of mat is *Campylium stellatum* (Schreb.) Bryhn. This species does not form a tufa but takes a large part in filling up bodies of water by growth upon the ground either submerged or emerging, and by aiding in the formation of a surface mat." "Wherever mosses appear, either floating or along the margin of ponds, they aid greatly in the conversion of depressions into land by promoting the advance of other terrestrial plants."

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[18] J. Braun-Blanquet, Plant Sociology. Translated, revised, and edited by G. D. Fuller and H. S. Conard, pp. 38, 307, 335. (1932). New York.

[19] W. H. Emig, Mosses as Rock Builders. Bryologist **21**, 25-27. (1918).

[20] Aravilla M. Taylor, Mosses as Formers of Tufa and of Floating Islands. Bryologist **22**, 38-39. (1919).

Mosses aid in the prevention of floods because of their ability to absorb water rapidly, to conserve moisture, and to lose it slowly.

On the other side of the ledger, moss is of economic importance in that there is cost in eradicating it in infertile bluberry fields on moist soil. Certain herbicides are recommended for controlling it on untillable land.[21]

On labels of some of the Fontinalis collections studied by the author, interesting comments contribute to the expense produced by these mosses. With a collection of *F. antipyretica* from Uinta River Canyon above Big Park, Utah, is the note that it is filling the pond above the old beaver dam. A collection of *F. Duriaei* from Cassia county, Idaho, in the Burley Irrigation District, is accompanied by the following data: "Submersed in canals, on hard bottoms, catches on most anything and holds silt, forming mounds in the canals. It is hard to kill and costs considerable to keep it out."

If one objects to mosses growing in the lawn, especially under or near trees, time and expense are required to eradicate them by means of chemical solutions, acid-bearing fertilizers, and proper plant foods for lawn and trees.

In conclusion, the peat mosses are of commercial value, today. From the utilitarian and dollar and cent point of view, true mosses and liverworts have only a few uses, if one defines use as that which immediately adds to man's material wealth, supplies man with nutritious food, or contributes in some way to man's comfort. But, quite to the contrary, if one regards the numerous general contributions and takes the long look both into the ages past and into the far distant future, in addition to the consideration of the present, an inestimable value may be placed on the direct and indirect economic importance of bryophytes to man. And, if one includes, also, scientific information, there is no doubt of the incorrectness of the statement, "Bryophytes are of little importance."

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[21] F. B. Chandler and I. C. Mason, Blueberry Weeds in Maine and their Control. Maine Ag. Exp. Sta. Bull. **443.** (1946). Orono, Maine.

ANTHROPOLOGY

Chairman: **Arthur B. Carr**, Indianapolis

William Wallace, Indiana University, was elected chairman for 1949.

ABSTRACTS

An Indiana Archaeological Field School, Glenn A. Black, Indiana University.—At the time the great prehistoric site known as the Angel Mounds Site was purchased it was recognized that it would be ideal for use as an outdoor laboratory for the teaching of correct archaeological methods. The large number of men who were available for use in exploration in the years 1939-1942 precluded the possibility of development of a Field School. In 1945, after Indiana University became interested in Indiana Archaeology, two students were accepted for training during the summer season. One student was taken in 1946 and two again in 1947. This period of experimentation proved so successful from the standpoint of the student and sponsor that steps were taken to make the school permanent and enlarged to accommodate a large group.

In 1948 facilities were ready for eleven students and these eleven spent ten weeks at fruitful field research during which time they became familiar with the actual problems which arise in the field and which cannot be covered in the class room. In 1949 facilities will be available for a still larger group and it is to be hoped that the twenty or more who will participate will be from several universities and from several geographical areas. With such representation will come a cross-fertilization of ideas which will make such a school all the more valuable in the years to come.

The Racial Affiliations of the Southern Utes. G. K. Neuman, Indiana University.—In his work among the Indian tribes of the "four-corners" region of the Southwest, the writer was able to take measurements and collect observations on a series of fifty-five full-blood Southern Utes. This constitutes the first successful attempt to collect anthropometric data of this tribe. The people are of small stature, rather heavily built, brachycephalic with high brain cases, and relatively wide noses. Their affiliations are with certain late tribes of the Southeast, central California, and Mexico. Plains influences are also discernible to a small degree.

Linguistics Without Meaning and Culture Without Words, C. F. Voegelin, Indiana University.—Linguists are aware of occasional attempts to find structure (or to state procedures for finding structures) without resorting to the usual distinctive features and meaning equivalences. That we actually resort to even this little in all the realm of meaning is only because it is heuristic to do so (it helps us find phonemes and morphemes). This is successful in the main but not entirely successful: loose ends in any operation involving meaning appear inescapable. The difficulty is one of statement, according to Preston (personal communication), who would make two restatements, one the converse of the other; in both of these it is understood that *units* are phonemes and morphemes: (1) in order to obtain semantic *units* (phonemes and morphemes), it is convenient to use semantic data; (2) in order to obtain non-semantic *units* (phonemes and morphemes), it is convenient to use non-semantic data. For strategy, we might agree with Preston, but we lack techniques to implement the strategy. Our techniques begin with arranging letters which represent the slow movements of muscles used in the production of sounds,—that is, we start with phonetics, not with semantic data, and yet in the general case of linguistic analysis, we have been influenced by consideration of meaning. Necessary or dispensable, this is the way it is actually done by linguistic analysts. That it is possible to avoid all meaning (equatable in part to the anthropologists' use of culture), has the advantage of avoiding loose ends, but to date, remains questionable on practical grounds: the operations employed when meaning is entirely abandoned might be prohibitively time consuming even if theoretically possible. It seems though that a computing machine with a "memory" would obviate these practical difficulties.

Anthropologists may state culture without bothering to give the terminology involved in the culture. When a rapid survey of a culture area or even a whole culture is assayed, terminology is apt to be regarded as dispensable; so also in some otherwise careful descriptions of material culture. This represents personal taste or judgment rather than a theoretical position. It seems fair to say that most anthropologists regard language, at least in its terminology aspect, as one of the ways of attesting cultural statements: obviously so in the case of kinship systems, social organization, and religion; implicitly so, in the case of material culture. In actual field practice, extraordinarily detailed terms are elicited on different parts of a basket or a house (and their manufacture); of plants and their gathering or cultivation (and their use); and indeed of all complex units of production and consumption.

Why many of these terms, elicited in the field, fail to find their way into the final published report of ethnographers is a not uninteresting question; but the fact that the terms are asked for at all suggests that they are regarded as culturally relevant by culturalists.

One paper considering the relationship of language and culture concluded that all linguistic meaning is referable to cultural statement, but questioned whether all aspects of culture are necessarily verbalized. The part that is, by definition, not verbalized has been called *covert culture;* so also, not all but some *themes* are derived from sources other than what the culture actualizing the theme has to say on the subject of the theme, which is then stated by the anthropologist but not talked about by the people whom the anthropologist is studying. This, culture without words, is now a definite theoretical position and has recently been treated in that part of theory concerned with ascribing value to cultures on the one hand, and on the other to patterns and configurations.

Unsolved Anthropological Problems of Costa Rica, ELIAS ADIS-CASTRO, Indiana University.—Because of extensive Spanish settlement, very little is left of the aboriginal inhabitants. The remaining Indians, perhaps 2000 of them, are found in the Talamanca and La Estrella areas of the country. Racially at least two elements seem to be represented: an earlier more gracile type and another whose affiliations are probably to South American tribes. Linguistically, there are similarly, Oto-Mangue relationships to the north and Chibchan ones to the south. Archaeologically only southern affiliations have been stressed, although others are almost certainly to be established.

Recent Anthropological Data on the Rhesus Factor, CHARLES E. CLAUSER, Indiana University.—In a recent study carried out on more than two hundred Indiana University students it was found that the large majority of Rh negative individuals represent the Iron Age Nordic physical type, and in nearly all the rest that there has been at least one near ancestor of that type. This strongly suggests that this reaction may be due to a mutation that originated comparatively recently in northwestern Europe.

Casual Observations on Angel Mounds Skeletal Material

Don W. Dragoo, Indiana University

Since the beginning of excavations at the Angel Site in Vanderburgh-Warrick counties, Indiana, a rather large amount of skeletal material has been recovered. This material represents the former inhabitants of the most interesting and spectacular aboriginal archaeological site in the state.

During the past summer a preliminary survey was made of this material for the purpose of giving a general picture of these aboriginal inhabitants and as a basis for further and more thorough study in the future.

Skeletal material from all forms of burial disposal, except cremation, has been recovered from this Middle Mississippi site. Burials of adults and children are found throughout the village area with infant burials quite commonly found beneath the floors of houses. Burials are extended, partly flexed and fully flexed. Of special interest are the many human bones found that are not associated with burials.

During the past few years 220 complete or nearly complete burials have been removed. A large number of isolated bones have been found but these have little statistical value. This site can be expected to yield several hundred more burials in future excavations.

From the observations made, a general picture of the individual and his life can be drawn. The average male was of medium stature with rather broad shoulders and heavy musculature. The areas of muscle attachment on the bones are well developed and in some individuals the areas are extremely marked. The head is relative large and probably mesocephalic or low brachycephalic in form. Many males appeared extremely round-headed because of vertico-occipital deformation of the skull during infancy.

Females were relatively short in stature and light in build. The head form varies, but this may be due to some deformation. A large percentage of the female crania so far examined are dolichocephalic and possess a bun-shaped occiput. This is somewhat disquieting in a population that would normally be expected to possess roundheads. When brachycephalic crania occur there usually is some deformation. With the securing of many more individuals in the future the statistical picture may greatly change in favor of brachycephals. The female crania so far recovered are more heterogenous than those of males.

Of special interest is the cranial deformation found in these skeletal remains. The majority of males exhibit this condition in slight to marked degrees. Only a few females have deformed crania, and when present, it is usually only slight. In most cases the deformation is confined to the occipital and posterior parietal regions of the skull. Deformation of the male crania has made measurements of only slight value in the majority of individuals. Some males show deformation to such a degree that the entire skull is effected.

Generally the health of the population was good for those individuals who were able to survive infancy and early childhood. The life expectancy of these people was rather high for a primitive group. Males could usually expect to reach the age of fifty with some individuals reaching the extremely old age of sixty. Females did not fair so well because of the rigors of childbirth in which many of them lost their lives.

Of the 220 complete or nearly complete burials recovered, 30 of them, or 14%, were of infants and children. This percentage is indicative of the high mortality rate among infants and the lower age groups. Miscarriages and abortions were common as indicated by foetus burials.

A number of pathologies appear in this material. Arthritis seems to have been the most common affliction in the Angel Site population. Approximately 70% of the individuals observed in this survey manifested arthritic lipping of the lumbar vertebrae and arthritic changes in the sacra in slight to marked degrees. Some fusion of the lumbar vertebrae also occurs.

Lesions are quite common in the long bones and apparently represent various types of periostitis, osteomyelitis, and different forms of bone destruction. Such conditions may have been due to any one of several causes, such as trauma, pyrogenic infection, and tuberculosis. A spongy condition of the bone occurs, which may have been due to syphilis.

Another relatively common pathological condition found in the long bones is that of exostosis. The tibia exhibited this condition most frequently.

Evidences of old fractures are not uncommon, particularly in the long bones and the ribs.

Ear exostoses appear in a few individuals, although the percentage is not as high as in some primitive groups. None of the females observed possessed this condition.

Evidence of infection of the mastoid processes appears in a few individuals.

Pathological conditions in the teeth were very common and represented a number of diseases and malformations.

The teeth of young individuals are relatively good but show some wear. Dental caries of all sizes, shapes, and conditions were extremely common in older individuals. Caries occurred most frequently in premolars and molars.

Many of the teeth showed abrasions of various types. In some cases the cusps were entirely worn off and the enamel lost from the entire surface.

Impacted molars were occasionally found, the condition being most often in the lower third molar.

The ante-mortem loss of pre-molars and molars is quite frequent in the upper age groups.

Infection of the roots of canines and pre-molars was rather common. In a few individuals this condition was severe and had caused the destruction of considerable areas of the maxillary bone. Occasionally this infection invaded the maxillary sinuses.

A typical example of the dental condition in the upper age group is that of a male approximately 55 years of age. The teeth are extremely worn. First, second, and third lower right molars are missing. Second and third lower left molars are missing. First and third upper left molars are missing. First and third upper right molars are missing. Three of the remaining teeth have large caries. This individual also possessed extreme lipping of the vertebrae due to arthritis which probably was caused by this dental condition.

The skeletal material from this site presents many interesting problems and deserves complete investigation in the future. Until such studies are made no definite conclusions can be drawn.

Archaeological Manifestations of Owen County, Indiana

Vernon R. Helmen, Indiana University

The Indiana Historical Bureau, aware that the archaeological past of the state becomes more difficult to recover and reconstruct with the passing of each year, has instituted county archaeological surveys that are conducted during the summer. The Bureau's hope is to eventually survey all areas of aboriginal occupation in the state. This season's investigations were carried on in Owen County.

The purpose of the survey was to determine the extent that projected flood control would effect sites in the county, as well as to determine the archaeology of the county as a whole. Initial work was made immeasurably easier by a preliminary survey made by Glenn A. Black (1) in 1932. Mr. Black kindly turned his unpublished notes over to the survey party, my wife and me.

Owen County, which is located approximately forty-five miles southwest of Indianapolis, is crossed diagonally from northeast to southwest by the west fork of White River. Eel river enters the north central portion of the county from the north and then bends almost due west to flow across the northwestern portion of the county almost to the Clay County line where it exits to the north. After looping around the county to the west, the Eel again enters in the southwest corner and flows due east for about one mile when it bends south and leaves Owen to enter Greene County.

We unceremoniously dubbed our survey method the "vacuum cleaner technique," for we tried to pick up all aboriginal material but the dirt on a site. This technique resulted in the collection of all flint chips, potsherds, and any boulders showing signs of artificial pecking or abrasion. During the evening, the material collected during the day was washed and examined for any interesting usage and the unworked material was discarded. We found that on ninety-five percent of the sites, amorphous flakes that exhibited very fine secondary chipping on one face and on a small portion of the edge of the flake were being picked up. On some of the sites, up to 60 percent of the total flakes collected showed this type of workmanship. A little experimentation showed us that we could duplicate these implements by taking an unworked flake and scraping on a stick with it. A few scrapes would form the implement, for the pressure put on the flake in scraping struck off flakes on one side only and formed a shallow concavity. It is evident then that these retouched flakes are only flakes that had been used once as a scraper, a few times at most, and then discarded.

The majority of the sites surveyed in the county and all of the major ones are located on rivers or close to them. The nine pottery bearing sites are all found in the valley of the White river. This is only logical for the semi-sedentary, semi-agricultural, pottery-making people who inhabited these sites would choose a location where good land was available for their corn. The bottoms of the White river have the best soil for corn in the county. Then too, the river offered easy transportation to these people who lived in this formerly heavily wooded area.

The large village sites in the southern part of the county, especially Hickam Village site, show certain relationships with Greene County material reported by Black. (2) The village is accompanied by two mound groups, one of eight small mounds, and one of four. These mounds tend to be grouped in three's a Green County trait. The mounds have been pitted in all but three instances and one mound was partially destroyed when a tree growing upon it blew over. Stone slabs in the interior of the mound are revealed in the hole caused by the fall of this tree; such slabs in mounds also occur in Greene County. The pottery from this site is the common grit-tempered, cord-marked Woodland ware. One of the large vessels found here is shown on page 250 of Lilly's "Prehistoric Antiquities of Indiana." (3) The village area was under cultivation this summer and many refuse pits were apparent, showing up as dark areas in the sandy soil on which the village was located. All of the arrowheads found at this site were of the notched or stemmed type, no triangular points occuring.

The Summit Village site in the northern portion of the county does not show this close relationship with Greene County. Here there is only an artificially modified knoll instead of a mound group, over half of the arrowheads are triangular, though of the wide-based woodland type. The pottery, while Woodland, exhibits modification in that all rim sherds recovered were maleated on the lip while the clay was still plastic. This resulted in beveling the rim in a distinctive manner not seen elsewhere in the county. This type of rim treatment is seen in Castle Creek Focus (Owasco Aspect) of New York State, as is the predominance of triangular points.

One other site, the Pectol Camp site on Rattlesnake Creek, shows interesting divergence. Here, in an area approximately 100 x 100 feet, we picked up on the surface more than twenty hand mullers and slab morters. No other site in the county produced so many of these implements, though hand mullers were quite common.

In summation, it can be said that Owen County was occupied by Woodland peoples though, as you can see, with variations from site to site. Hickam Village site and the Summit Village site need to be examined more closely to determine the extent of their divergence and their relationships to other areas.

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2. Black, Glenn A., The Archaeology of Green County, Indiana History Bulletin, Vol. X, No. 5, 1933.

3. Lilly, Eli, Prehistoric Antiquities of Indiana, Indiana Historical Society, Lakeside Press, R. R. Donnelley & Sons Company, Chicago, 1937.

BACTERIOLOGY

Chairman: M. S. A. Campbell, Indiana State Board of Health

Robert P. Ervin, Notre Dame, was elected chairman for 1949.

ABSTRACTS

Comments on Aerating Liquids by Shaking

Opal B. Starks and H. Koffler, Purdue University*

Although agitating submerged cultures of certain microorganisms on shaking machines has become a popular method of supplying microorganisms with oxygen, the question of exactly how much oxygen this procedure makes available to them is still open. The following approach was used to obtain at least some preliminary answers to this question: One hundred and fifty ml of freshly boiled and rapidly cooled distilled water, sometimes containing added substances, in 500 ml Erlenmeyer flasks were agitated at 28°C on a reciprocating shaker, having a 4 inch stroke and shaking at a rate of 85 strokes per minute. At zero time and intervals thereafter the amount of oxygen dissolved was determined by the Winkler method. The rate at which oxygen diffused into distilled water during the first 30 seconds was approximately 300 ppm of O_2 per hour, and 50 ppm of O_2 per hour, when the liquid was still. The addition of glucose to give a 0.5 percent solution did not appreciably alter the rate of diffusion; the addition of gum arabic on the other hand reduced the rate of oxygen diffusion as well as the total amount of oxygen dissolved after 3 hours, probably because it increased the viscosity of the liquid. When nitrogen was bubbled from a sintered-glass aerator through a 2.5 percent solution of gum arabic, a thick foam developed, which completely covered the solution and inspite of agitation stayed intact for about an hour. As long as this foam persisted, the diffusion of oxygen was almost completely prevented. The foams that commonly form during actual shake-flask fermentations may not interfere as seriously with aeration as did the gum arabic foam in these experiments; nevertheless, to guarantee an adequate supply of oxygen considerable foaming should be avoided by the addition of suitable antifoam agents. When "penicillin defoamer" was added to the solution of gum arabic, no foam developed and diffusion of oxygen into the solution proceeded fairly rapidly.

Some Biological Properties of Circulin, an Antibiotic from Bacillus Circulans. O. W. Kaufmann, P. A. Tetrault, and H. Koffler, Purdue University.—*In vitro* circulin very effectively inhibited representatives of the following genera: *Aerobacter, Brucella, Escherichia, Klebsiella, Neisseria, Pseudomonas, Salmonella,* and *Shigella.* In general, gram-negative bacteria were more sensitive to polymyxin than to circulin; the opposite was true for gram-positive bacteria. A polymyxin-resistant strain of *Pseudomonas aeruginosa* was less resistant to circulin than it was to polymyxin. The LD_{50} for circulin, given to white mice by single intraperitoneal injections, was approximately 68 mg per kilogram. One hundred percent of the mice survived after having received daily intraperitoneal injections of 45 mg per kilogram for 10 days. Preliminary experiments indicated that circulin protected white mice against 100 minumum lethal doses of *Klebsiella pneumoniae* given intraperitoneally.

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Influence of Incubation Temperatures on the Demonstrable Amount of PR8, Lee-B and FM-1 Strains of Influenza Virus in the Chorio-Allantoic Fluid of Chick Embryos

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The chick-embryo in the past few years has become increasingly important as an experimental host for influenza virus as well as being used for the commercial production of influenza virus vaccine. Many investigations have been conducted to ascertain the specific roles of a number of variables which are known to be involved in the relationship between the infective agent and the host. Some of the variables which have been studied are (a) the concentration of the virus in the inoculum, (b) the length of time of incubation of the infected embryos, (c) the age of the embryos at time of inoculation, (d) the temperature of incubation of the embryos before inoculation, and (e) the temperature of incubation of the infected embryos. Relative to the studies conducted concerning the temperature of incubation of the infected embryos the investigators have used on the most part small numbers of eggs in conducting their studies. It has been our experience, from a production view point in which as many as 100,000 eggs are inoculated per week, that one is not always able to obtain the same results when using a large number of eggs as an investigator who has published data in which only a few eggs have been used, though one endeavors to conduct ones production methods in an identical manner to the experimental methods. Miller (1) has conducted some studies upon the production of A virus (PR8 strain) at various temperature levels and found maximum virus production to occur when the embryos were incubated at 35°C. Beard (2) and his group of co-workers at Duke University suggest 39°C. while Henle (3) suggests 36-37°C. for this same strain. In studies upon the production of B virus (Lee strain) at various temperature levels Beard (4) found maximal infectivity as well as greater hemagglutinative activity when the embryos were incubated at 35°C. No reference in the literature could be found concerning the optimal temperature level for the production of the A virus (strain FM-1). This particular strain was isolated in 1947 and the National Institute of Health had all producers of influenza virus vaccine to substitute this strain for the Weiss strain which had formerly been included in their mixed vaccine product. The results obtained with all three strains of the influenzal virus are described in the present paper.

Materials and Methods

Stock Inoculum.—Infectious allantoic fluid obtained by the regular passage of the particular strain through eggs for seed purposes was used. The PR8 strain contained around 250 units of CCA activity per cc. (5) The Lee strain 100 and the FM-1 strain 100.

Inoculations.—Eggs for the experiments were obtained from a commercial hatchery which also supplies us with our eggs used for production purposes and had been incubated 11 days at 37.5°C. The eggs were inoculated, into the chorio-allantoic sac, at room temperature with 0.2 ml of a suitable dilution in saline of the stock virus by means of a mechanical egg inoculating machine developed in our own laboratories and capable of inoculating 6000 eggs per hour. The openings in the shells were not sealed since we have found it is unnecessary to do so. The eggs were then incubated for 48 hours at the desired temperature range, and the humidity kept at a high level. At the end of the 48 hour incubation period the eggs were candled and all dead embryos discarded. The eggs having living embryos were then chilled for approximately 24 hours at the end of which time the allantoic fluid was aspirated and tested for CCA activity.

Measurements of Virus Activity.—Assuming that virus infectivity and chicken red blood cell agglutination (CCA) activity are the properties of the same molecule (6), the relative amounts of virus were measured indirectly by means of determinations of CCA titers. The CCA titrations were carried out according to the method of Hirst and Pickels (7), as modified by Miller and Stanley (5).

Experimental Results

Table I shows the results of three separate trials using PR8-"A" virus at incubation temperatures of 33°-35°C., 35°-37°C., and 37°-39°C. In trial 1 it will be noted that the CCA titer of the eggs incubated at 33°-35°C. and 35°-37°C. is indentical while that of the eggs incubated at 37°-39°C., is less than one-third this amount. Trial 2 shows practically the same relation existing between the various temperature levels as did trial 1. In trial 3 the eggs incubated at 35°-37°C. had a slightly higher CCA value than those incubated at 33°-35°C. It will be noted in all three trials that the eggs incubated at 37°-39°C. had a much higher death rate than those incubated at the two lower levels. It was because of the much higher death rate at 37°-39°C. that the number of eggs inoculated in trials 2 and 3 for incubation at this level was reduced in comparison to the number inoculated for incubation at 33°-35°C. and 35°-37°C. A total of 1008 eggs was used in these three trials.

TABLE I

The red blood-cell hemagglutinative and CCA activity of chorioallantoic fluid from chick embryos incubated at various temperature levels after inoculation with PR8 influenzal virus.

Incub. Temp.	Trial	Length of Incub. Hrs.	No. Eggs Inoc.	Death Rate %	CCA Value
33°-35°C	1	48	118	11.85	250
	2	48	137	22.6	125
	3	48	150	10.0	225
35°-37°C	1	48	119	15.8	250
	2	48	137	30.7	125
	3	48	150	20.0	250
37°-39°C	1	48	119	63.8	70
	2	48	50	78.0	50
	3	48	28	100.0	. .

Table II shows the results of three separate trials using Lee "B" virus at incubation temperatures of 33°-35°C., 35°-37°C., and 37°-39°C. In trial 1 it will be noted that the CCA titer of the eggs incubated at 33°-35°C. and 35°-37°C. is identical while that of the eggs incubated at 37°-39°C. is practically nil. The results obtained from the 37°-39°C. incubation temperature substantiated previous tests not included in this paper and consequently no further tests were repeated at this temperature level. Trials 2 and 3 both indicate very little difference in virus activity between the two temperature levels. Comparing the death rate of the embryos at the various temperature levels there was 2.2% less deaths in the group incubated at 33°-35°C. than there was in the group incubated at 35°-37°C. The 37°-39°C. group again had a much higher death rate in comparison to the other two groups. Beard (8) suggests that the small quantity of Lee "B" virus demonstrable in the chorio-allantoic fluid of embryos incubated at 39°C. may be due to the inactivation or breaking down of the virus that is formed by exposure to adverse pH of the chorio-allantoic fluid, as the fluid descends into the acid region at 39°C. Miller (9) has found that the optimum pH range for the stability of influenza virus B is at or above pH 7.9 while that for optimum stability (9) of PR8-"A" is 6.5 to 7.0. A total of 1234 eggs was used in the study of the Lee B virus.

TABLE II

The red blood-cell hemagglutinative and CCA activity of chorio-allantoic fluid from chick embryos incubated at various temperature levels after inoculation with Lee "B" influenzal virus.

Incub. Temp.	Trial	Length of Incub. Hrs.	No. Eggs Inoc.	Death Rate %	CCA Value
33°-35°C	1	48	132	3.8	100
	2	48	204	11.2	150
	3	48	145	7.6	100
35°-37°C	1	48	273	6.0	100
	2	48	203	12.3	125
	3	48	145	11.0	100
37°-39°C	1	48	132	18.2	10
	2	Not Repeated			
	3	Not Repeated			

Table III shows the results of the trials made using the FM-1 virus. Trial 1 indicates about twice as much CCA activity in the chorio-allantoic fluid from the embryos incubated at 35°-37°C. than those incubated at 33°-35°C. and 10 times more than from the embryos incubated at 37°-39°C. Trials 2 and 3 indicate a slightly greater amount of CCA activity

TABLE III

The red blood-cell hemagglutinative and CCA activity of chorio-allantoic fluid from chick embryos incubated at various temperature levels after inoculation with FM-1-"A" influenzal virus.

Incub. Temp.	Trial	Length of Incub. Hrs.	No. Eggs Inoc.	Death Rate %	CCA Value
33°-35°C	1	48	104	24	50-75
	2	48	150	20	60
	3	48	100	16	125
35°-37°C	1	48	104	12.5	125
	2	48	150	26	80
	3	48	100	7	150
37°-39°C	1	48	104	15.3	10
	2	48	150	16	5
	3	48	100	12	50

in the chorio-allantoic fluid from the embryos incubated at 35°-37°C. than from those incubated at 33°-35°C. Only small amounts of CCA activity is indicated by trials 2 and 3 as being present in the chorio-allantoic fluid of the embryos incubated at 37°-39°C. Relative to the death rate of the embryos during the 48 hour incubation period there was approximately 5% less deaths in the 35°-37°C. range as compared to the 33°-35°C. group. There was a total of 1062 eggs used in this study of the FM-1strain.

The authors of this paper feel that mention should be made of the fact that some investigators, i. e. Salk (10), feel that conditions of cultivation of the various strains within the ddifferent laboratories may also have an effect upon many strain and line differences that are noted. If this be true, then the differences in optimal incubation temperature for the production of PR8 virus, that is mentioned by the different investigators in the beginning of this paper, can be explained. This same fact might also explain the findings of the present authors relative to the optimal temperature level of incubation for the production of PR8 and Lee virus being the same, as the seed for each strain has been carried in an identical manner in regard to the temperature of incubation since we received the original strains in 1944. Incubation of the seed has always been done in the same incubator in which our production eggs are incubated, and because of the size of this incubator room we have a temperature variation of at least ±1° at 36°C. Our present findings would seem to indicate that we would have more FM-1 virus produced if we incubated this strain at 35°-37°C. while 33°-35°C. would optimum for the production of the PR8 and Lee virus using the particular strains which we have in our laboratory.

Summary

1. Very little, if any, difference in demonstratable PR8 virus as measured by the CCA test and the hemagglutination test was noted between the chorio-allantoic fluid of eggs incubated for 48 hours at 33°-35°C. and 35°-37°C.

2. Very little difference in demonstratable Lee virus as measured by the CCA test and the hemagglutination test was noted between the chorio-allantoic fluid of eggs incubated for 48 hours at 33°-35°C. and 35°-37°C.

3. From an economic view point, because of a lower embryo death rate, the optimum temperature level of incubation would be 33°-35°C. for the particular strains of PR8 and Lee virus which we have in our laboratory.

4. The optimum temperature level of incubation for the maximum production of FM-1 virus in the present experiments was 35°-37°C.

5. The present experiments indicate that the 37°-39°C. temperature level of incubation was unsuitable for the cultivation of any one of the three strains studied.

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The Use of Lysozyme in Studies With a Bacterial Virus

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In the field of virology available evidence points toward the probability that the cells, in which multiplication occurs, provide metabolic organization required for virus synthesis, and that the virus, in some way, supplies a directive influence. Cells of *B. coli* infected with T_2 bacteriophage are incapable of normal growth and division though their metabolism continues at a high rate (1). This metabolism is now directed toward synthesis of nucleic acids and proteins which eventually become a part of the multiplying virus.

Although little information is available concerning the processes which occur in biological synthesis of nucleic acids and proteins, conditions necessary for a number of biological synthetic reactions have recently been ascertained. Since a number of these can be demonstrated in cell-free media, the hope is nurtured that virus multiplication in cell-free media may be possible. From time to time reports have been published that this has been accomplished (2). None of these claims have as yet been substantiated by other groups. It is evident, however, that the discovery of conditions permitting virus reproduction in the absence of cells would make available an important new tool for virus work. For this reason it is desirable that this possibility be reinvestigated from time to time as additional knowledge concerning viruses and concerning the biochemistry of cellular metabolism becames available.

The experiments reported in this paper gave no indication of reproduction of bacteriophage. The presentation of this work appears justified in order that undue repetition by others may be avoided, and in the hope that the considerations which led to the choice of conditions for these experiments may be suggestive for further fruitful experimentation.

A medium containing all possible cellular components appeared to offer the best opportunity for success. An attempt was made to choose conditions which would:

(a). Provide a method of cell lysis in which intracellular constituents (enzymes, proteins, etc.) would not be denatured or destroyed. For this purpose lysozyme, which presumably acts only on the cell wall, was chosen. It was consequently necessary to choose a lysozyme-sensitive organism which serves as a host for a virus. *Staphylococcus aureus* strain K_1, and P_1 bacteriophage* were chosen to fill this requirement.

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* The Staphylococcus aureus K_1 and bacteriophage P_1 were obtained from Dr. A. P. Krueger.

(b). Maintain a high concentration of constituents in order that dissociation of enzyme-coenzyme combinations would be minimized.

(c). As far as possible avoid autolysis. In many of the experiments sufficient lysozyme was added to give considerable lysis in a brief period. Phage was always added to the lysate as promptly as possible. Cooling was also used to decrease the rapidity of autolytic reactions.

During the course of the work, in personal conversation with Dr. Krueger, we learned of his experiments with the same organism, phage, and with lysozyme in which an average increase of phage of 180 percent was observed. Dr. Krueger very kindly informed us of the conditions of his experiments (3). The first four experiments in Table I are typical of a larger series which we have conducted. No significant increase of phage was observed.

In these experiments one percent of egg white was added to a bacterial culture containing 1-2 x 10^9 cells per ml. and lysis was allowed to proceed for twelve minutes. Cells which had not been lysed were removed by filtration through a super-cel pad prepared according to the method of Krueger, Scribner, and Brown(4). The cell-free filtrates were collected in a chilled flask, inoculated with phage, and held at 5^0 for thirty minutes. Phage assays were made by the plaque count method of Hershey, Kalmanson and Bronfenbrenner (5).

Experiments 5 (a) and (b) (cf. Table I) were conducted in similar manner with addition of 0.85% and 2.3% NaCl respectively to the laysates before addition of phage. Utter, Krampitz, and Werkman (6) had reported that addition of sodium chloride to lysed preparations of *Micrococcus lysodeikticus* made possible the demonstration of enzymatic activities which were not observable in salt-free lysates.

In experiment 6 pyruvate, Mg^{++}, $PO_4^{\equiv}$, sodium chloride, potassium chloride, adenosinetriphosphate, and cytochrome c were added to the lysate before addition of phage. Several workers have recently reported observations that cellular preparations maintained in media containing these substances are able to carry out a number of complex enzymatic oxidations (7).

Experiments have also been conducted varying from the above in other respects. If phage reproduction is directly associated with enzymatic manifestations of the virus or the host, such enzymatic activity probably should occur more readily at 36° than at 5°. For this reason use of the higher temperature was also investigated. In addition, in many experiments crystalline lysozyme has been used with a somewhat longer period of lysis of host cells. Removal of unlysed cells was accomplished by use of a Berkfeld filter. Experiment 1, Table II represents one of the experiments of this group illustrating variation in the time of lysis. It seemed possible that the period of cellular invasion by phage might be eliminated by use of lysates. In this event multiplication might occur in a shorter interval than that observed with intact cells. In experiment 2, the effect of varying periods of incubation of phage and lysate was studied. It will be noted that no indication of multiplication was noted at either short or longer intervals.

TABLE I. Incubation of Bacteriophage in Bacterial Lysates.

Expt. No.	Amt. Lysis 12 Min. (1/100 Egg White)		Phage Added	Phage Found After 30 Min. at 5°		Egg White in Saline
	From	To		Bacterial Filtrate	Bacterial Lysate	
1.	1.2×10^9	5.3×10^8	2.0×10^6	2.4×10^6	2.8×10^6	
2.	1.4×10^9	8.5×10^8	1.5×10^6	1.4×10^6	1.6×10^6	1.1×10^6
3.	1.2×10^9	5.0×10^8	5.3×10^5	4.2×10^5	3.9×10^5	3.9×10^5
4.	1.5×10^9	6.4×10^7	5.0×10^4	6.1×10^4	6.0×10^4	7.5×10^4
5. (a)	1.8×10^9	6.9×10^8	1.9×10^6	1.4×10^6	1.6×10^6	1.3×10^6
(b)				1.6×10^6	1.8×10^6	1.6×10^6
6.	1.0×10^9	9.4×10^7	9.2×10^5	5.9×10^5	5.7×10^5	6.9×10^5

TABLE II. Incubation of Bacteriophage in Bacterial Lysates

	Time Lysis	Amt. Lysis	Phage Added	Phage Found After 10 Mins. at 36°		
				Bacterial Filtrate	Bacterial Lysate	Egg White in Saline
1.	4 hrs.	8.4 x 10^{9} 7.4 x 10^{8}	4.0 x 10^{5}	7.3 x 10^{5}	2.2 x 10^{5}	3.1 x 10^{5}
	2 hrs.	8.4 x 10^{9} 2.4 x 10^{9}	4.0 x 10^{5}	4.2 x 10^{5}	2.4 x 10^{5}	
	30 min.	8.4 x 10^{9} 4.2 x 10^{9}	4.0 x 10^{5}	3.7 x 10^{5}	5.6 x 10^{5}	
2.	12 min.	1.1 x 10^{9} 3.6 x 10^{8}	1.0 x 10^{6}	(10 min.) 9.2 x 10^{5}	7.4 x 10^{5}	8.9 x 10^{5}
				(30 min.) 1.2 x 10^{6}	7.2 x 10^{5}	8.3 x 10^{5}
				(75 min.) 8.5 x 10^{5}	9.0 x 10^{5}	6.1 x 10^{5}
				(120 min.) 7.8 x 10^{5}	7.0 x 10^{5}	7.3 x 10^{5}
3.	2½ hrs.	(a. cell free)	3.0 x 10^{4}	6.0 x 10^{4}	7.0 x 10^{4}	
	2½ hrs.	(b. 2.5 cells per ml.)	3.0 x 10^{4}	5.7 x 10^{4}	1.2 x 10^{5}	
	2½ hrs.	(c. 2,500 cells per ml.)	3.0 x 10^{4}	3.0 x 10^{4}	3.1 x 10^{4}	
4.	4 hrs.	(unfiltered) 1.9 x 10^{9} 3.9 x 10^{8}	8.4 x 10^{5}	2.7 x 10^{5}	5.4 x 10^{5}	
5.	4 hrs.	2.8 x 10^{9} 1.9 x 10^{8}	2.2 x 10^{5}	a) 2.7 x 10^{5}	1.9 x 10^{5}	2.9 x 10^{5}
				b) (3 mg./ml. of ATP) 1.8 x 10^{5}	2.0 x 10^{5}	2.4 x 10^{5}

It seemed possible that rapid destruction of enzymes or other labile materials necessary for phage reproduction might account for failure to obtain phage increase. Continuing lysis of a few cells might provide a supply of such materials. In experiment 3, the three parts represent bacterial filtrates to which (a). no cells were added; (b). 2-3 cells per ml. were added; and (c). 2500 cells per ml. were added to the lysate prior to addition of phage. In experiment 4 the filtration to remove cells was omitted. No significent increase in phage was observed. Similarly addition of adenosinetriphosphate to provide a source of energy for synthetic reactions was without effect.

Thus, to date we have not been successful in demonstrating significant increase in phage in lysozyme-lysates.

Cohen (8) has recently obtained evidence consistent with the interpretation that intracellular phage formation may proceed at a constant rate starting at the time of infection and terminating with lysis of the cell. In contrast, the work of Latarjet (9) indicated that the formation of phage was not completed until just before lysis. It occurred to us that lysis of infected cultures by lysozyme during the "constant period" might provide evidence bearing on this point, for demonstration of an increase in phage would strongly indicate formation of additional phage before the usual time of lysis.

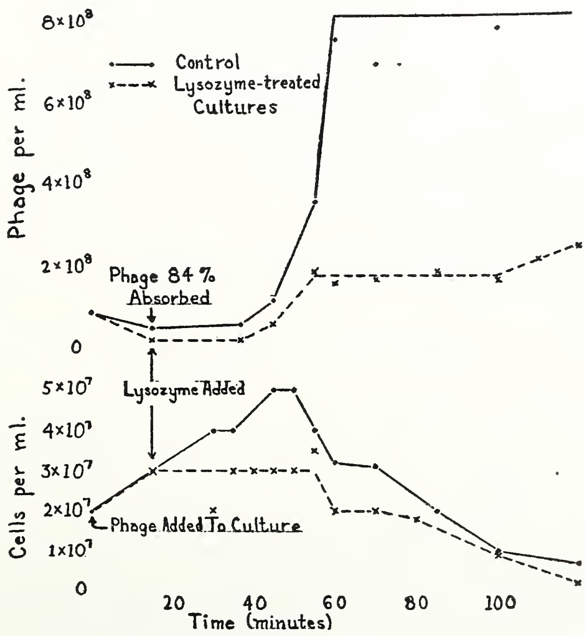

Fig. 1. Effect of addition of lysozyme to *Slophylococcus aureus* K^1 infected with P_1 phage.

Young (2½ hr.) cultures of *Staphylococcus aureus* K_1 in nutrient broth were infected with phage P_1. After 6-15 minutes egg white was added to experimental tubes and an equal volume of broth to the controls. The cultures were incubated at 37° with aeration, and aliquots were removed at intervals for assay. Figure I illustrates the findings in a representative experiment. The phage increase in control and lysozyme-treated cultures occurred at the same time, although a smaller increase was repeatedly observed with the latter. Efforts were made to determine whether lysozyme acted on infected cells. Unfortunately, a considerable portion (10-90 percent) of the bacteria were uninfected in spite of the fact that the phage to bacteria ratio was as high as 25 to 1. No conclusions were possible.

Use of lysozyme failed to provide evidence of phage increase prior to the normal time of lysis. The decrease in burst size in comparison with control cultures suggests the following possibilities: (a). lysis of some infected cells at a stage at which phage is incompletely formed and is therefore inactive, (b). destruction by lysozyme of some materials necessary for phage formation, or (c). action on cell walls, thereby changing their permeability and affecting the supply of nutrients to the cell.

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BOTANY

Chairman: H. J. Brodie, Indiana University

R. A. Laubengoyer, Wabash College, was elected chairman for 1949.

ABSTRACTS

Variation in the bird's nest fungus, Cyathus Stercoreus, in culture and in nature. Harold J. Brodie. Indiana University.—A long series of haploid mycelia, all derived from spores of a single peridiole of one wild type specimen of the cophrophilous fungus *Cyathus stercoreus,* when paired in certain combinations yielded diploid strains that differed from one another in color, texture and growth rate. A number of the diploid mycelia were induced to fruit in culture, and these produced fruit bodies of several different types, some so unlike the parental wild type as to bear little superficial resemblance to *C. stercoreus.* Ten of the culture types were planted outdoors in garden soil enriched with manure. Two such cultures fruited after six months, and in each instance produced fruit bodies essentially identical with those obtained in the laboratory. The extreme variability of this fungus noted in collections from nature probably has a genetic basis.

Growth patterns of carrot and sunflower roots cultivated in vitro. C. W. Hagen, Jr., Indiana University.—Excised carrot (Red-cored Chantenay) and sunflower (Mammoth Russian) roots may be cultured indefinitely in White's solution containing thiamine, pyridoxine, and nicotinic acid. Both species exhibit two growth patterns, a "normal" and a "hyperhydric" type. The normal differs from the hyperhydric in its higher growth rate, more regular contour, greater opacity, higher content of intercellular gas, and its tendency to float near the surface of the culture fluid. Parallel clones of the two types may be maintained provided the normal clone is repeatedly subcultured by excision of tips of lateral roots. Apical meristems of the normal type invariably transform to the hyperhydric type within ten weekly transfers. The reverse transition has never been observed. Some evidence bearing on the nature of the transition has been accumulated.

Right-handed and left-handed corn embryos. Paul Weatherwax, Indiana University.—A seedling grass plant may be designated as right-handed or left-handed according to the direction in which the edges of the lowest leaf sheath overlap. An old publication on the structure of the ear of corn states that, in the normally paired rows of grains, the embryos in one row are right-handed and those in the other are left-handed. The problem has been reinvestigated and the statement found to be erroneous. Whether a corn plant is to be right-handed or left-handed is determined wholly by chance and is in no way correlated with the position of the embryo in the characteristic pair of grains.

The Devonian-Mississippian Transition Flora of Indiana and Kentucky. Part I: Geological Aspects. J. H. HOSKINS AND A. T. CROSS.—The flora of the black shales of southern Indiana and correlative beds in Kentucky, Tennessee, and Ohio is represented by abundant petrified fragments of wood preserved in phosphatic nodules or as isolated, phosphatized specimens embedded in the matrix which contains the nodules. These fossils are fairly numerous in certain areas of the outcrop of the black shales but they are known only from the upper few feet of this series, i.e., in that portion which is considered to be Mississippian in age.

The upper part of the Devonian portion of the black shale series contains the better known silicified trunks of Callixylon Newberryi, and the lower part contains a zone of abundant, carbonized compressions of Foerstia. These two plants are found in beds of equivalent and slightly earlier age in the Ohio Black shale and the Chattanooga shale. Other species of Callixylon are found in near-equivalent and somewhat older beds in New York and in the upper part (Mississippian) of the New Albany shale.

A few species of plants found in the phosphate nodule zone (L. Miss.) of this region are possibly similar to some species less well known from beds considered to be Upper Devonian, in age, from New York. In general, this flora corresponds to that recorded from similar black shale deposits of Europe, and is not easily identified as being typically Mississippian or Devonian. The flora represented here by the petrified wood may be the equivalent of one of the fairly well known Middle or Upper Devonian impression floras of eastern North America or/and Europe.

The Devonian-Mississippian Transition Flora of Indiana and Kentucky. Part II: Paleobotanical Aspects. J. H. HOSKINS AND A. T. CROSS.—The flora of the New Albany shale based on the structure of petrified plant fragments is comprised of about 35 genera and 50 species. This assemblage represents a Devonian-Mississippian transition flora, for it reflects to a certain extent the vegetation considered typical of Middle and Upper Devonian and it also includes a number of genera better known from the Mississippian and even later geologic periods. But by far the majority of species and even genera are known only from the New Albany shale or from rocks of comparable age and character.

The Pteropsida and Cycadofilicales are the most varied groups present and also the most abundant. The genera Kalymma, with a number of species, and Calamopitys are most commonly found. The morphology and range of 24 of the most common genera are reviewed and illustrated.

Increased Survival Value Resulting from Apparently Deleterious Mutations in Oenothera. RALPH E. CLELAND, Indiana University.—

Oenothera has suffered a number of kinds of alteration in its hereditary mechanism which would seem to militate against its success in the struggle for existence. Reciprocal translocations tend to result in non-disjunction and consequent reduction in fertility. Lethals reduce fertility drastically. Self-pollination tends to reduce heterozygosity and the beneficial effects of hybrid vigor. It would seem that plants possessing all three of these would be handicapped indeed. Instead, the groups of Oenothera which are characterized by all three are the most vigorous, the most fertile and the most widely distributed groups in the genus. Oenothera illustrates how it is possible for seemingly deleterious mutations to combine in such a way as to bring increased rather than decreased survival value. Thus, in Oenothera, translocations occur in such a way that they do not bring about significant reduction in fertility, and hence translocated chromosomes do not tend to become eliminated through selection. This brings about increased heterogeneity in segmental arrangement resulting in large circles. When circles are present, lethals become advantageous since a single pair of balanced lethals can preserve the heterozygosity of all of the chromosomes with minimal reduction in fertility, thus insuring the maximum of hybrid vigor. Self-pollination, by insuring heavy pollination, overcomes the sterilizing effect of the lethals, and in turn the lethals prevent self-pollination from reducing heterozygosity and hybrid vigor. Thus it is seen that mutations which by themselves are capable of producing harmful effects may, when properly combined, add up to increased survival value in the struggle for existence.

Forest Type Control in the Versailles Park Area Ripley County, Indiana. J. E. POTZGER, Butler University.—The Versailles Park area (Ripley County) differs somewhat from most locations in Indiana in that the microclimatic control of forest types is more complex because of the compact, leached flats habitat. North-facing slopes and gentle south-facing slopes have mixed mesophytic forest (with beech-maple tendencies), south-facing slopes are primarily oak-hickory, flood-plains have the usual sycamore-elm-hackberry association, and the compact, poorly drained flats are invaded primarily by the beech-sweet gum-red maple association. This latter type forest yields to the climax mixed mesophytic forest readily when stream cutting of a few feet in depth introduces better drainage, and no doubt better aeration of the soil. Significant features are that in this change beech and sour gum persists in the new association, sweet gum drops out completely, red maple, tulip poplar and white oak are reduced to scattered representation. The chief invader of the modified habitat is sugar maple, while red oak, black walnut, and linden become minor representatives in the new association complex. Physical characteristics of the soil and lack of adequate aeration appear to be the most vital edaphic factors in determining the establishment of the sweet gum-beech-red maple Illinoian tillplain forest type.

Forests Past and Present on Isle Royale (A preliminary report). J. E. POTZGER, Butler University.—Isle Royale in Lake Superior has at present a striking boreal type of forest in which black spruce and white spruce are perhaps the most important species. Associated with these conifers is white birch. The forest as a whole is marked by small stem-size of trees except for some arbor vitae in swampy locations. The present forest cover may very likely be a post-fire forest. This conclusion is also supported by pollen studies from bogs on the island. The initial forest was composed chiefly of black spruce and Jack pine, with very small representation of paper birch.

The Laboulbeniales: An Interesting but Rare Group of Fungi. HAROLD J. BRODIE, Indiana University.—Despite the extensive monographical work by Thaxter, few mycologists appear to have attempted to find or study the Laboulbeniales. These fungi may have considerable phylogenetic significance because of their supposed relationship to the Red Algae. Too little is known of the life cycle and cytology of the group and it is suggested that they should be sought and studied. The writer has found specimens of the Laboulbeniales twice in Central Canada and once near Ann Arbor, Michigan, on the wing covers of water beetles and caribid beetles. The fungi most commonly found were *Laboulbenia Gyrinidarum*, Thaxter, and *L. flagellata*, Peyritsch.

Establishment and Growth of Seedling Reproduction of Sugar Maple (Acer Saccharophorum)

DANIEL DENUYL, Purdue University

Reproduction of sugar maple *(Acer saccharophorum)* is very common in the beech-maple woods of Indiana from which livestock have been excluded and which are not burned. Even in the oak-hickory woods sugar maple regeneration is commonly found along with elm, ash, hickory, and oak. The question that frequently arises is "What happens to the sugar maple seedlings and how many survive and grow into saplings, poles, and larger sized trees?" An answer to these questions comes from the records of permanent sample plots which were established in 1931. The purpose of these plots was to study the natural regeneration in woods from which livestock and fire were excluded. Quadrats 1/1000 acres in size were laid out and on these reproduction of all tree species was tagged. Measurements on many of the quadrats were taken annually for 5 years after which time periodic measurements were made. It is from these records that the establishment and growth habits of sugar maple will be described.

Sugar maple is a frequent and abundant seed producer. During the period 1931-1947 it was observed that in the woods where sample plots were located that 9 years out of 17 were good seed years.

Following an abundant seed crop thousands of newly germinated seedlings will be present in the woods. In some woods a dense carpet of seedlings numbering up to 1½ million per acre will become temporarily established. In other woods patches of dense sugar maple reproduction will be present. To illustrate what happens to the seedling population a record of one typical quadrat is presented.

TABLE 1. Sugar Maple Regeneration on a 1/1000 Acre Quadrat Height Classes in Feet

Year	0.5	1	2	4	6	8	Totals
			Numbers of Seedlings				
1932	1350						1350
1933	600	15					615
1934	300	67					367
1935	232	96					328
1937	25	100	9				134
1938	34	110	19				163
1939	71	35	51	6			163
1940	44	49	34	35			162
1942	23	10	9	5	1		48
1944	18	8	6	6	2	1	41
1947	12	9	5	5	2	2	35

The number of sugar maple seedlings shown in the 0.5 foot height class does not represent all of the seedlings that start growing because measurements were taken in July or August and so some seedlings had already died before counts were made. Observations show that many seedlings become temporarily established but do not persist and grow into the larger height classes. The marked drop in numbers between 1935 and 1937 was in a large measure due to the hot dry season of 1936. Measurements were not made in August 1936 because most of the seedlings appeared to be dead. The record of 1937 and the years following indicate that many seedlings survived and some have grown into the larger height classes. The figures also show that the mortality is high even of maple that seems to be well established, as is indicated by the number present in 1947. Although the quadrat record shows 9 sugar maples four feet or more in height in 1947, it is apparent that this number will be reduced as competition for space becomes more intense.

To illustrate what may happen to sugar maple saplings a record of the growth of trees in the smaller diameter classes is shown for trees growing in a woods where sugar maple constitutes 60% of the trees in the overhead stand.

TABLE 2. Growth of Sugar Maple per Acre

Diameter Class (inches)	Number of Trees			
	1932	Percent	1947	Percent
1	12	26		
2-3	8	17	18	39
4-5	20	43	12	26
6-7	6	14	10	21
8-9			6	14
	46	100	46	100

Although there was no mortality of the trees during the 15 year period, there is a marked change in the diameter class distribution. As these smaller maples compete with the larger trees in the stand some of them will eventually die.

Records of individual trees shed some interesting light on the growth of sugar maple. A maple tree 5.1 inches dbh in 1932 grew to a diameter of 5.8 inches in 10 years. In 1942 competing trees were cut and this sugar maple added 1.2 inches to its diameter during the 5 years, 1942-47, which is almost twice the growth previous to the removal of its competitors. Numerous examples of a similar response could be given. However, not all trees respond in this way but this record illustrates that some trees may grow into the larger diameter classes while others of the same size may lose out in the competition or fail to respond to changed growing conditions. In many regeneration quadrats it was observed that other hardwood species may offer sugar maple serious competition for growing space. Elm is an interesting example and often the number of young sugar maple seedlings may be reduced as elm seeds in and becomes temporarily established.

Summary

An initial stand of over 1 million sugar maple seedlings per acre will be reduced in 15 years time to 35 thousand or less. Following this many decades of competition for growing space will result in the establishment of a sugar maple woods composed of approximately 40 sugar maple trees per acre with 30 to 40 other hardwood associates. For sugar maple to maintain its position in a beech-maple woods it appears that an initial establishment of large numbers of seedlings is necessary to insure a satisfactory distribution of saplings, poles, and young timber sized trees.

Notes on Indiana Liverworts—I*

Kenneth A. Wagner, University of Tennessee

This paper begins a series dealing with the taxonomic, ecological, and other problems concerning the liverworts known to occur in Indiana. The results of two collecting trips in June 1947 are reported, together with other data compiled during the past year. Two species, *Cephalozia pleniceps* and *Riccardia palmata*, are reported for Indiana for the first time. All collections cited are deposited in the DePauw University herbarium and in the herbarium of the University of Tennessee.

Cephalozia pleniceps (Austin) Lindb. Parke Co., Turkey Run State Park, on sandy soil along Sugar Creek, Sept. 4, 1946, Wagner 1327; on sandstone along Sugar Creek, Sept. 4, 1946, Wagner 1318.

Cololejeunea Biddlecomiae (Austin) Evans. Union Co., on bar, woods 4 miles north of Liberty, June 6, 1947, Wagner 1409.

Conocephalum conicum (L.) Dum. Brown Co., on soil along stream, Brown County State Park, June 8, 1947, Wagner 1429. Huntington Co., Oct. 1946, Fred Loew.

Frullania eboracensis Gottsche. Blackford Co., on bark, woods 6-7 miles northwest of Pennville, June 4, 1947, Wagner 1403. Jay Co., on tree, 2 miles north of Red Key, June 4, 1947, Wagner 1422.

Frullania riparia Hampe. Brown Co., on bark, Brown County State Park, June 9, 1947, Wagner 1433. Randolph Co., with moss, 8 miles south of Union City, June 8, 1947, Wagner 1404. Wells Co., on tree trunk, woods 3 miles west of Poneto, June 4, 1947, Wagner 1418.

Lophocolea heterophylla (Schrad.) Nees. Blackford Co., on decayed wood, 6-7 miles northwest of Pennville, June 4, 1947, Wagner 1401. Brown Co., on humus, Brown County State Park, June 8, 1947, Wagner 1423. Jay Co., on decayed wood, 2 miles north of Red Key, June 4, 1947, Wagner 1420.

Metzgeria conjugata Lindb. was first reported for Parke County by Dorothy Parker in volume 51 of the proceedings of this Academy. The location of the collection was Turkey Run State Park. The present writer also collected this species at Turkey Run (Wagner 1325) and examined 26 other collections, all from that same area. Why only one station has been found for this species in Indiana presents a problem and the answer is not apparent at this time. The range of *M. conjugata* is rather general in the United States. It occurs from Maine to Florida and Louisiana, in the Pacific coast states, in Tennessee, Kentucky, Indiana and Wisconsin. It might be found in cool sandstone raivnes such as occur at Fern and Fallen Rock, and all collectors should look for it.

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* Contributions from the Botanical Laboratory, The University of Tennessee.

Porella platyphylla (L.) Lindb. Blackford Co., in woods, 6-7 miles northwest of Pennville, June 4, 1947, Wagner 1402.

Porella platyphylloidea (Schwein.) Lindb. Brown Co., on tree base, Brown County State Park, June 8, 1947, Wagner 1431. Jay Co., in woods, 2 miles north of Red Key, June 4, 1947, Wagner 1420. Posey Co., May 13, 1934, W. H. Welch 7820. Union Co., on tree base, woods 4 miles north of Liberty, June 8, 1947 Wagner 1408.

Preissia quadrata (Scop.) Nees. Brown Co., on damp hillside, Brown County State Park, June 9, 1947, Wagner 1431.

Reboulia hemisphaerica (L.) Raddi. Brown Co., on soil, Brown County State Park, June 8, 1947, Wagner 1425.

Depauperate growth of this species is easily confused with similar growth of *Preissia quadrata*. Examination of a good cross section of the thallus will enable the observer to readily distinguish between these two species, but such sections are sometimes difficult to make, especially for the beginner. The writer examined numerous collections of both species and found that there is a consistent difference in the rhizoids which can be observed with a handlens. When dry, the rhizoids of *R. hemisphaerica* glisten; those of *P. quadrata* do not. This difference in light reflection apparently is due to the greater number of pegs in the rhizoids of the former species. The rhizoids are also smaller, ranging from 6 to 21 microns in cross section, the majority being about 15 microns. The rhizoids of *P. quadrata* range from 7 to 37 microns in cross section, the majority being from 20 to 30 microns.

Scapania nemorosa (L.) Dum. Brown Co., on soil along stream, Brown County State Park, June 9, 1947, Wagner 1432.

Notes on Indiana Liverworts—II. Porella in Indiana*

KENNETH A. WAGNER, University of Tennessee

PORELLA L.

Plants dark green to brown, 1-7 mm. wide, 1-12 cm. long, often forming extensive but rather loose mats; stems 1-3 pinnately branched; rhizoids wanting to numerous, arising from the base of the underleaves. Leaves incubous, complicately bilobed, the dorsal lobe larger; median leaf cells of the dorsal lobe 18-36 microns in diameter, approximately isodiametric; underleaves always present, conspicuous. Gemmae are reported for only a few tropical species. Plants dioecious. Male and female inflorescences on short lateral branches, and, in both, the lobes of the bracts about equal in size. Perianth large, often 2 lipped.

Key to the species

A. Plants growing submerged, 2-4 mm. wide.............*P. pinnata*

AA. Plants not growing submerged, 2-7 mm. wide.

  B. Plants 4-7 mm. wide; lobule lanceolate to linear-oblong, its width less than one half that of the underleaf; insertion of the underleaf transverse; trigones of the leaf cells bulging; median leaf cells 24-35 microns...........*P. pinnata*

  BB. Plants about 2 mm. wide; lobule lingulate, its width at least half that of the underleaf, often equal to or wider than the underleaf; insertion of the underleaf crescentic; trigones of the leaf cells prominent but not bulging; median leaf cells 16-26 microns...............................*P. platyphylla*

P. pinnata is easily identified by the very small, narrow ventral lobes. It occurs on tree bases and exposed roots, occasionally on limestone and cement. Usually it is found in a more moist habitat than is *P. platyphylla*. It appears twice in the above key because of differences between the submerged and terrestrial plants. Those plants growing in water are much narrower, and the leaf cells are correspondingly smaller, ranging from 18 to 26 microns in diameter.

Recent literature on Indiana liverworts lists another specific name, *platyphylloidea*, in the genus *Porella*. In 1947 the author reported this as a species from 15 counties (4). The majority of identifications of *P. platyphylla* and of *P. platyphylloidea*, however, were always accompanied by some uncertainty. Following the work of Ammons (1) and Evans (2), the specimens were referred to whichever species the majority of the plant seemed to fit. Evans has pointed out that all of the vegetative characteristics intergrade between the two extreme forms. Figures 2 and 3 represent such extremes and are not difficult to classify in a system which maintains the validity of both *P. platyphylla* and *P. platyphylloidea.* There is difficulty, however, when an attempt is made to refer to one species a plant having characteristics of both extremes. Figures 4 and 5 were drawn from the same plant.

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* Contributions from the Botanical Laboratory, The University of Tennessee, N. Ser. 106.

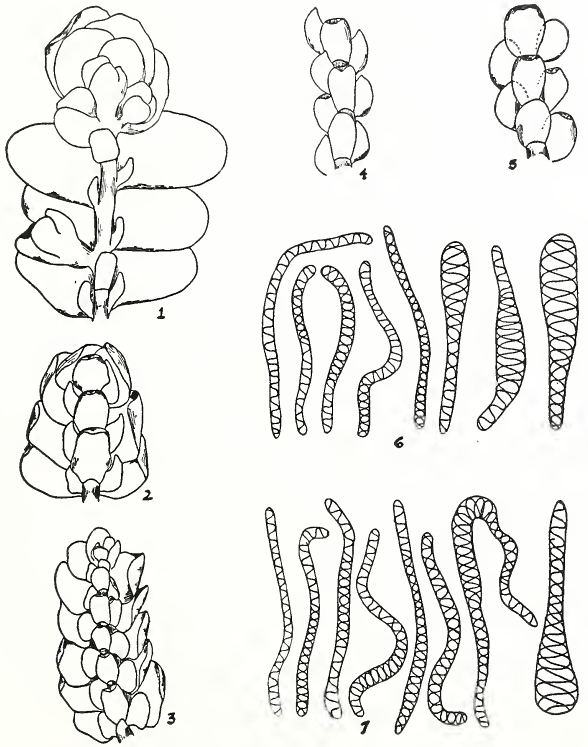

Fig. 1. *Porella pinnata,* ventral surface. Fig. 2 and 3, extreme forms of *P. platyphylla.* Fig. 4 and 5, underleaves and lobules from two branches of the same plant. Fig. 6, elator types from a plant similar to Fig. 2. Fig. 7, elator types from a plant similar to Fig. 3.

Evans' final conclusion is that the elators alone show consistent differences in the two species. He restricts the name *P. platyphylla* to those plants producing only bispiral elators. The elators of *P. platyphylloidea* have a single spiral in the majority of cases. He notes that rarely elators are found to have two spirals in the middle, but are never bispiral throughout.

Frye and Clark (3), in reducing *P. platyphylloidea* to a variety of *P. platyphylla,* put somewhat different limitations on the elators. *P. platyphylla* is described as having elators with 1-3, usually 2 spirals to the end. The variety, then, has elators with only 1 spiral for half the length, or throughout.

Figure 6 shows the types of elators found in the capsules of a plant having the gametophytic characteristics of *P. platyphylla.* Figure 7 shows elator types of a plant which, otherwise, would key to *P. platyphylloidea,* or to the variety if Frye and Clark is followed.

These diagrams show that the spirals of the elators cannot be used to separate the blunt lobuled forms either as a distinct species or as a variety. In view of this situation plus the fact that the vegetative extremes may be found on the same plant, it is believed that *P. platyphylloidea* (Schwein.) Lindb. and *P. platyphylla* var. *platyphylloidea* (Schwein.) Frye and Clark should be listed as synonyms of *P. platyphylla* (L.) Lindb.

In making this reduction, only the following seven Indiana counties must be added to the list of those already published for *P. platyphylla*: Brown, Jay, Morgan, St. Joseph, Scott, Union, and Washington. This brings to 44 the total number of counties in Indiana in which this species has been found. There is no reason to believe, though, that it does not occur in every county.

REFFERENCES

1. Ammons, N., A manual of the liverworts of West Virginia. Am. Mid. Nat. **23**, 3-164, 1940.

2. Evans, A. W., Notes on New England hepaticae—XIII. Rhodora **18**, 82-85, 103-106, 109-119. 1916.

3. Frye, T. C. and L. Clark, Hepaticae of North America. Univ. of Wash. pub. in Biology **6**, 721-724. 1946.

4. Wagner, K. A., Additional distribution records of hepaticae in Indiana. Proc. Indiana Acad. Sci. **56**, 86-91. 1947.

Higher Fungi of Marion County, Indiana

John O. Cottingham, Indianapolis, Indiana

The following is a list of fleshy, leathery and woody fungi which have been found by my assistants and myself since my report to the Indiana Academy of Science, October 1947. Our report at that time listed 192 species. We are now adding 46 more or a total of 238 species thus far found and identified in Marion County. Many species that should be indigenous have not yet been found and while this list is very incomplete, it does give the mycologist a good idea of what he may expect to find most frequently in the center of Indiana.

AGARICACEAE

Agaricus arvensis, Fr.; *Collybia fusipes* (Bull); *Collybia maculata*, A. & S.; *Collybia hariolorum*, Fr.; *Clitopilus popinalis*, Fr.; *Clitocybe dealbata*, Fr.; *Cortinarius duracinus*, Fr.; *Hygrophorus flavo-discus*, Frost.; *Lactarius piperatus*, Fr.; *Lentinus Ursinus*, Fr.; *Lenzites vialis*, Pk.; *Mycena alcalina*, Fr.; *Marasmius foetidus*, Sow.; *Panus stipticus*, Bull.; *Pholiota rugosa*, Pk.; *Pholiota squarrosa*, Mull.; *Pholiota mutabilus*, Schaeff.; *Pholiota curvipes*, Fr.; *Psilocybe foenisecii*, Fr.; *Russula ochrophylla*, Pk.; *Tricholoma sulphureum*, Fr.; *Tricholoma album*, Schaeff.; *Collybia hygrophoroides*, Pk.

POLYPORACEAE

Polyporus Berkeleyi, Fr.; *Polyporus pensylvanicus*, Sumst.; *Polyporus chioneus*, Fr.; *Polyporus radiatus*, Fr.; *Polyporus pergamenus*, Fr.; *Polyporus frondosus*, Fr.; *Polyporus fumosus*, Fr.; *Polyporus tephroleucis*, Fr.; *Polyporus sanguineus*, Fr.; *Boletus bicolor*, Pk.; *Boletus luteus*, L.; *Poria corticola*, Fr.; *Poria attenuata*, Pk.; *Poria medulapanis*, Pers.; *Trametes rigida*, Bert. and Mont.

LYCOPERDACEAE—*Calvatia gigantea*, Pers.

HYDNACEAE

Hydnum erinaceus, Bull.; *Hydnum albonigrum*, Pk.; *Hydnum ochraceum*, Pers.

THELOPH ORACEAE—*Sterum rameale*, Schw.

ASCOMYCETES—*Peziza vesiculosa*, Bull.

Studies in the Stromatic Sphaeriales of Indiana—II[1]

EMORY G. SIMMONS, DePauw University

This paper is the second in a series of taxonomic reports covering the stromatic members of the order *Sphaeriales.* An attempt is made here to organize and to complete, where possible, the scattered and often unrelated or incomplete data concerning the Indiana species of the family *Diatrypaceae,* and to present it in such a manner that it will form a workable basis for future taxonomic investigation or for classroom determination of collections.

During the preparation of this study specimens were available from the following institutions: DePauw University (DPU)[2]; Indiana University (IU); Miami University (MU); New York Botanical Garden (NY); and Wabash College (WAB).

DIATRYPACEAE

Diatrypeae Winter, in Rabenhorst, *Kryptogamen-Flora.* 1 (Div. II): 810. 1887.

Diatrypaceae Lindau, in Engler and Prantl, *Die Natürlichen Pflanzenfamilien.* 1 (Div. I): 472. 1897.

Stromata composed entirely of fungus elements (stroma and host not mixed), effused, pulvinate, shield-shaped, or tuberculiform. Conidial and ascigerous stages characteristically on different stromata. Perithecia monostichous or polystichous with their ostiola separately erumpent. Ascospores small, cylindrical, usually curved, allantoid, hyaline or light brown unicellular.

Key to the Genera

Asci 8-spored . . . . *Diatrype*
Asci with more than 8 spores . . . . *Diatrypella*

DIATRYPE Fries

Diatrype Fries, Summa Veg. Scand. 385. 1849.

Valseutypella Hoehnel, Ann. Mycol. 16:224. 1918.

Ectosphaeria Spegazzini, Bol. Acad. Cordoba, 25:48, ill. 1921.

Stromata effused or isolated, ectostroma deciduous, exposing a widely erumpent entrostromatic disk. Perithecia parallel, separately erumpent. Ascospores eight, allantoid, yellowish. Imperfect stage ectostromatic.

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[1] A portion of a major thesis (A Monographic Study of the Indiana Species of the Stromatic Sphaeriales) presented to the Faculty of the Department of Botany, DePauw University, in partial fulfillment of the requirements for the degree Master of Arts, June 1946.

[2] These abbreviations are used in locating specimens referred to in the citations following each species description throughout this paper.

Key to the Species

1. Stromata greenish-yellow .... 7. *D. virescens*
   Stromata (mature) light brown to black 2
2. Stromata 2 cm. in length to widely effused 3
   Stromata variously pulvinate but not exceeding 4 mm. in longest diameter 4
3. Perithecia closely packed; asci (sp. p.)[3] 25-30 microns long .... 5. *D. platystoma*
   Perithecia evenly distributed; asci (sp. p.) 30-50 microns long .... 6. *D. stigma*
4. Ascospores 12-16 microns long .... 1. *D. albopruinosa*
   Ascospores not exceeding 12 microns in length 5
5. Asci (sp. p.) 40-45 microns long .... 4. *D. hochelagae*
   Asci (sp. p.) less than 40 microns in length 6
6. Ostiola prominent, erumpent; stromata 1.5-2.5 mm. in diameter .... 2. *D. asterostoma*
   Ostiola small, obtusely conical, slightly projecting; stromata 2-3 mm. in diameter .... 3. *D. disciformis*

1. *Diatrype albopruinosa* (Schweinitz) Cooke

Sphaeria albopruinosa Schweinitz, Syn. fung. N. Am. 195. 1831.

Diatrype albopruinosa (Schweinitz) Cooke, Grevillea, 13:37. 1885.

Diatrype roseola Winter, Journ. Mycol. 1:121. 1885.

Diatrype Durieui Montagne, in Herb. Curtis (fide Ellis & Everhart, N. Am. Pyr. 570. 1892.)

Diatrype Webberi Ellis & Everhart, in Herb. E. & E. (fide Ellis & Everhart, N. Am. Pyr. 570. 1892.)

Eutypella sheariana Berlese, Icon. Fung. 3:68. 1905.

Stromata scattered or subgregarious, sometimes confluent, suborbicular, 1.5-2.5 (exceptionally 3-4 mm. broad, slightly convex, surrounded by the ruptured epidermis, whitish when young and fresh, becoming finally dark brown, light-colored inside, surface becoming more or less fissured. Perithecia 10-30 in a stroma, crowded ovate or elliptic-oblong. Ostiola more or less prominent, 3-5 sulcate-cleft, black. Asci oblong-clavate, long-stipitate, sp. p. 55-65 x 7 microns. Ascospores heaped together, allantoid, obtuse, slightly curved, 12-16 x 2.5-4 microns, yellow-brown.

Specimens examined:

Clay Co.: May 19, 1928, Shaw (IU).

Monroe Co.: on oak, Bloomington, April 1909, Wood (IU).

Tippecanoe Co.: on oak wood, Lafayette, April 18, 1899, C. Riddle (MU).

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[3] Sp. p. is used here to indicate measurements of the spore-containing portion of the ascus.

Most of the non-effused species of Diatrype are separated with difficulty because of their macroscopic resemblances to each other. Spore and ascus measurements remain the best differential characters and are effective in separating *D. albopruinosa* (Schw.) Cke. from similar species. The asci and ascospores of *D. albopruinosa* are constantly larger than are those of *D. hochelagae* E. & E., *D. disciformis* (Hoffm.) Fr., and *D. asterostoma* Berk. & Curt.

2. *Diatrype asterostoma* Berkeley & Curtis

Diatrype asterostoma Berkeley & Curtis, Grevillea, 4:96. 1875.

Stromata wart-like, erumpent, scattered or subconfluent, 1.5-2.5 mm. in diameter, embraced at the base by the ruptured epidermis, externally black (white inside). Perithecia 10-20 in a stroma, globose, black, abruptly contracted into slender necks rising through the white substance of the stroma, with prominent, stellate-cleft, erumpent ostiola. Asci clavate, long-stipitate, sp. p. 25 x 4-5 microns, 8-spored. Ascospores allantoid, nearly hyaline, moderately curved, 6-10 x 1.5-2 microns.

Specimens examined:

Montgomery Co.: Rattlesnake Ravine, S. W. Crawfordsville, April 13, 1946, Simmons 1251 (DPU).

Morgan Co.: on fallen beech limb, ravine N. E. Martinsville, Sept. 20, 1941, Simmons 1252 (DPU).

Union Co.: on beech twigs, in open pasture, July 21, 1917, Fink 26 (MU).

This species is readily separated from *D. albopruinosa* (Schw.) Cke. and *D. hochelagae* E. & E. by reason of its smaller asci. However, distinctions made between *D. asterostoma* Berk. & Curt. and *D. disciformis* (Hoffm.) Fr. are so slight that *D. asterostoma* appears to be little more than a variety of D. disciformis. Differentiation between the two is made by means of the smaller stromata and more prominent ostiola of *D. asterostoma.*

3. *Diatrype disciformis* (Hoffmann) Fries

Sphaeria disciformis Hoffman, Veg. Crypt. 1:15. 1787.

Sphaeria depressa Sowerby, Eng. Fung. Vol. 2, pl. 216. 1799.

Sphaeria grisea DeCandolle, Flore Fr. 2:122. 1805.

Diatrype disciformis (Hoffman) Fries, Summa Veg. Scand. 385. 1849.

Stromata scattered or gregarious, flattened-pulvinate, round, 2-3 mm. in diameter, discoid, erumpent and loosely embraced by the ruptured epidermis, dark brown, whitish inside, base sunken to the wood and circumscribed by a black line. Perithecia 20-30 (or more) in a stroma, ovate, about 0.75 x 0.5 mm., closely packed and subangular, with short necks and small, obtusely conical, smooth or 3-5-cleft, slightly projecting ostiola. Asci clavate, long stipitate, sp. p. 22-30 x 4-5 microns. Ascospores subbiseriate, allantoid, yellowish, slightly curved, 6-8 x 1.5-2 microns.

Specimens examined:

Montgomery Co.: on bark of dead limb, below dam, Sugar Creek, Crawfordsville, Spring, 1929, A. R. Bechtel 832 (WAB).

Ascus measurements of *D. disciformis* (Hoffm.) Fr. serve to distinguish it from both *D. albopruinosa* (Schw.) Cke. and *D. hochelagae* E. & E. Characteristics of *D. disciformis* and of *D. asterostoma* Berk. & Curt., as have been stated in previous remarks, are so similar, however, that varietal placement of *D. asterostoma,* if not actual synonymy, should be the proper treatment of the two.

4. *Diatrype hochelagae* Ellis & Everhart

Diatrype hochelagae Ellis & Everhart, Proc. Acad. Nat. Sci. Phil. 42:224. 1890.

Stromata orbicular or elongated, 2-3 mm. long and 1-2 mm. wide, often more or less confluent, pulvinate-verrucose, with the margin abrupt or slanting off at the ends, with a faint circumscribing black line which does not penetrate deeply into the wood, dull black outside, dirty white within. Perithecia crowded in the stroma, subglobose, about 0.5 mm. in diameter, with black, thick, leathery walls. Ostiola conic-hemispherical, deeply 4-5 sulcate-cleft. Asci (sp. p.) 40-45 x 7-8 microns, with stout paraphyses. Ascospores allantoid, yellowish, moderately curved, 8-12 x 2.5 microns.

Specimens examined:

Monroe Co.: on pear, Bloomington, Feb. 12, 1931, Amidei (IU).

Mature stromata of *D. hochelagae* E. & E. are scarcely separable from those of *D. albopruinosa* (Schw.) Cke. by macroscopic means. However, the differences between the two with respect to spore and ascus measurements (pointed out in the key to the species) are so constant that there is little probability of confusing these species.

5. *Diatrype platystoma* (Schweinitz) Ellis & Everhart

Sphaeria platystoma Schweinitz, Syn. fung. Car. 43. 1822.

Diatrype discostoma Cooke, Grevillea, 6:144. 1878.

Diatrype platystoma (Schweinitz) Ellis & Everhart, N. Am. Pyr. 566. 1892.

Stromata effused or, oftener, in suborbicular patches 1-2 cm. across or elongated 2-4x0.5-1 cm., soon erumpent, about 1 mm. thick, margin abrupt, slaty-black or black. Perithecia monostichous, ovate-oblong, 0.5-0.75 mm. high, closely packed. Ostiola prominent, hemispherical, entire or 4-sulcate. Asci (sp. p.) 25-30 x 4 microns, stipitate. Ascospores subbiseriate, allantoid, hyaline, 6-8 x 1.5 microns.

Specimens examined:

Monroe Co.: on maple, Bloomington, 1911, Owens (IU).

Morgan Co.: on decaying, decorticated wood, ravine N. E. Martinsville, Sept. 20, 1941, Simmons 1141 (DPU); on loosened bark of dead beech limb, ravine N. E. Martinsville, Sept. 20, 1941, Simmons 1147 (DPU).

Putnam Co.: on dead herbaceous stem, DePauw Arboretum, Oct. 25, 1945, Simmons 1136 (DPU); on dead limbs of ironwood, DePauw Arboretum, Oct. 25, 1945, Simmons 1138 (DPU); on fallen, rotting elm limb, DePauw Arboretum, Nov. 13, 1941, Simmons 1140 (DPU); on fallen oak branch, valley E. Bainbridge, Oct. 17, 1941, Simmons 1142 (DPU); on dead branch of beech, DePauw Arboretum, Nov. 13, 1941, Simmons 1144 (DPU); on upright weathered post, Hoosier Highlands, Sept. 16, 1941. Simmons 1160 (DPU).

Specimens of *D. platystoma* (Schw.) E. & E. and *D. stigma* (Hoffm.) Fr. frequently are found to be separated with difficulty. Both are effused forms of Diatrype and both become black or nearly black at maturity. *D. platystoma* usually is noticeably the more coarse of the two by reason of its slightly larger perithecia and ostiola. Ascus measurements show these of *D. platystoma* to be less than those of *D. stigma.*

6. *Diatrype stigma* (Hoffman) Fries

Sphaeria stigma Hoffman, Veg. Crypt. 1:7. 1787.

Sphaeria decorticans Sowerby, Eng. Fungi, Vol. 2, pl. 137. 1799.

Sphaeria decorticata DeCandolle, Flore Fr. 2:289. 1805.

Sphaeria undulata Fries, Syst. Mycol. 2:350. 1823.

Diatrype undulata Fries, Summa Veg. Scand. 385. 1849.

Diatrype stigma (Hoffman) Fries, Summa Veg. Scand. 385. 1849.

Stictosphaeria Hoffmanni Tulasne, Sel. fung. carp. 2:49. 1863.

Diatrype stigma Cesati & DeNotaris, Schema Sfer. Ital. 26. 1863.

Eutypa micropuncta Cooke, Grevillea, 6:144. 1878.

Diatrype Dearnessii Ellis & Everhart, in E. & E. North American Fungi, 2nd Ser. #2526. (fide Ellis & Everhart, N. Am. Pyr. 565. 1892.)

Diatrype tennissima Cooke, in Ravenel, Fungi Americani. (fide Ellis & Everhart, *loc. cit.).*

Sphaeria concolor Schweinitz, in Herb. Schweinitz. (fide Ellis & Everhart, *loc, cit.).*

Sphaeria subcutanea Wahlenberg, in Herb. Schweinitz. (fide Ellis & Everhart, *loc, cit.*)

Stromata widely effused, continuous or interrupted, often surrounding the limb, sometimes extending for several inches in length, at first covered by the epidermis, finally exposed, brownish or dusty-white, becoming darker or nearly black, whitish inside, definitely limited but irregular in outline, 0.5-1 mm. thick, sometimes undulate and of unequal thickness, the thinner parts then often sterile. Perithecia monostichous, evenly distributed, ovate, small, with short necks and punctiform, discoid, depressed-hemispherical or conical, entire or 4-cleft ostiola. Asci clavate-oblong, 8-spored, sp. p. 30-50 x 4-8 microns. Ascospores subbiseriate, allantoid, brownish, 6-9 x 1-1.5 microns.
Specimens examined:

Montgomery Co.: in Crawfords' Wood, Crawfordsville, Jan. 25, 1917, D. P. Miller (MU, WAB); Turners' Wood, S. W. Crawfordsville, May 21, 1941, Simmons 1101 (DPU).

Putnam Co.: on fallen branches, Hoosier Highlands, Sept. 16, 1941, Simmons 1137 (DPU).

Wabash Co.: on dead beech, Roann, March 20, 1908, Daisy G. Lewis (DPU).

This species is often collected in Indiana during its young stages, at which time the stroma is light brown or dusty-white in color. It commonly is found to encircle completely small dead branches. It can be separated from *D. platystoma* (Schw.) E. & E., which it greatly resembles, by reason of its constantly larger asci.

7. *Diatrype virescens* (Schweinitz) Ellis & Everhart

Sphaeria virescens Schweinitz, Syn. fung. N. Am. 195. 1831.

Diatrype disciformis (Hoffman) Fries var. *virescens* Berkeley, Grevillea, 4:95. 1875.

Diatrype virescens (Schweinitz) Ellis & Everhart, N. Am. Pyr. 569. 1892.

Stromata scattered, erumpent-superficial, orbicular, about 2 mm. in diameter, depressed-pulvinate, surrounded at the base by the ruptured epidermis; disk greenish-yellow, powdery, becoming darker with age. Perithecia monostichous, covered by the waxy, whitish substance of the stroma, about 0.33 mm. in diameter, 10-15 in a stroma, necks terminating in obstusely conical, 4-cleft, black ostiola barely erumpent through the greenish disk. Asci (sp. p) about 35 x 5 microns, stipitate, 8-spored. Ascospores subbiseriate, allantoid, yellowish, moderately curved, 7-9 x 1.5-2 microns.

Specimens examined:

Monroe Co.: on beech, Bloomington, July, 1938, Lohman (IU).

Montgomery Co.: on dead branches, Crawfordsville, H. W. Anderson (MU); on *Tilia sp.*, Camp Rotary, near Crawfordsville, Nov. 18, 1945, A. R. Bechtel (DPU); on dead beech branches, Lybyar farm, S. W. Crawfordsville, Nov. 22, 1941, Simmons 1146 (DPU).

Putnam Co.: on beech limb, Greencastle, Jan. 22, 1908, Daisy G. Lewis (DPU); Fern, Sept. 1893, L. M. Underwood (DPU); on dead beech limb, Greencastle, May 25, 1908, Daisy G. Lewis (DPU).

D. virescens (Schw.) E. & E. is rarely confused with any other pulvinate species of Diatrype. The small yellow-green, cushion-like stromata are found to retain their color for many years under herbarium conditions, specimens examined in the course of this study often being as much as 38 years old.

DIATRYPELLA Cesati & DeNotaris

Diatrypella Cesati & DeNotaris, Schema Sfer. Ital. 29. 1863.

Stromata effused or isolated, ectostroma absent or strongly developed but not deciduous; entostroma well developed, often pustulate but usually not widely erumpent, bounded by a dark marginal zone. Perithecia usually clustered, rarely separately erumpent. Ostiola usually sulcate. Asci long-stipitate, polysporous. Ascospores 1-celled, allantoid, yellow-hyaline. Imperfect stage primarily ectostromatic.

Key to the Species

1. Asci large, more than 80 microns long .... 4. *D. quercina*
   Asci less than 80 microns long 2
2. Asci less than 60 microns long .... 3. *D. prominens*
   Asci more than 60 microns long 3
3. Ostiola 3-4 stellate-cleft; entostroma whitish .... 1. *D. Cephalanthi*
   Ostiola entire; entostroma greenish .... 2. *D. Frostii*

1. *Diatrypella Cephalanthi* (Schweinitz) Saccardo

Sphaeria Cephalanthi Schweinitz, Syn. fung. Car. 7. 1882.

Diatrypella Cephalanthi (Schweinitz) Saccardo, Syll. fung. 1:209. 1882.

Stromata scattered, 2-3 mm. in diameter, scarcely penetrating to the wood, at first small and subtubercular-erumpent, black, apex generally traversed by a single longitudinal, deep furrow (giving the appearance of an Hysterium), but this furrow soon obliterated as the apex of the stroma protrudes itself still further, assuming an orbicular or elliptical form, 1-3 mm. in diameter, and roughened by the protruding, black, rough subconical ostiola which are 3-4 stellate-cleft. Perithecia 6-20 in a stroma, closely packed, ovate or subangular, about 0.5 mm. in diameter, lying in and covered by the scanty whitish substance of the stroma; walls thick, black leathery; necks short. Asci fusoid, 110-115 (sp. p. 75-80) x 8-10 microns, polysporous, stipitate, paraphysate. Ascospores allantoid, yellow-hyaline, not strongly curved, 6-9 x 1.5 microns.

Specimens examined:

Putnam Co.: on Cephalanthus, Fern, December 1892, L. M. Underwood (NY). determined by Ellis as "*Diatrype Cephalanthi?*"

The collection cited above is still in excellent condition and yields numerous multi-spored asci and the subhyaline, slightly curved ascospores typical of species of Diatrypella.

The stromatic pustules of Diatrypella species are so similar to each other and to pulvinate species of Diatrype that determination of members of this group depends almost entirely upon ascus observations. *D. Cephalanthi* (Schw.) Sacc., as it is described, can be separated from *D. quercina* (Pers.) Nke. and *D. prominens* (Howe) E. & E. by ascus measurements and from *D. Frostii* Peck by reason of its whitish entostroma and stellate-cleft ostiola in contrast to the greenish entostroma and entire ostiola of *D. Frostii.*

2. *Diatrypella Frostii* Peck

Diatrypella Frostii Peck, Bot. Gaz. 3:35. 1878.

Stromata wart-like, 1-2 mm. in diameter, seated on the inner bark which is slightly blackened and marked around each stroma with a circumscribing line penetrating to the wood, erumpent, surrounded and partly covered (except the apex) by the ruptured epidermis, black outside, greenish within, forming a white spot on the wood beneath. Perithecia ovate-globose, 10-15 in a stroma, 0.33-0.5 mm. in diameter. Ostiola vary from obtuse-conical to subelongated, conic-cylindrical, entire, often obscure. Asci polysporous, cylindric-clavate, stipitate, paraphysate, sp. p. 75-80 x 12-15 microns. Ascospores yellowish, allantoid, moderately curved, 7-8 x 2 microns.

Specimens examined:

Monroe Co.: on *Acer sp.*, Bloomington, Amidei (IU).

D. Frostii Peck, as is true with other species of Diatrypella, can best be determined by means of ascus measurements. Separation from *D. Cephalanthi* (Schw.) Sacc., which it greatly resembles, is by its characteristically greenish entostroma and entire ostiola.

3. *Diatrypella prominens* (Howe) Ellis & Everhart

Diatrype prominens Howe, Bull. Torr. Bot. Club, 5:42. 1874.

Diatrypella prominens (Howe) Ellis & Everhart, N. Am. Pyr. 592. 1892.

Stromata wart-like, orbicular or angular, 1-1.5 mm. in diameter, erumpent and closely encircled by the ruptured epidermis, subprominent, black outside, whitish inside. Perithecia 4-8 in a stroma, subglobose, about 0.33 mm. in diameter, necks short, with their ostiola obtusely conical, slightly prominent and finally broadly and irregularly perforated. Asci clavate-stipitate, 75-80 (sp. p. 40-60) x 10-12 microns, paraphysate, polysporous. Ascospores allantoid, yellow-hyaline, moderately curved, 6-8 x 1.0-1.5 microns.

Specimens examined:

Monroe Co.: on sycamore, Bloomington, April 13, 1910, J. M. Van Hook 2768 (IU).

Montgomery Co.: on dead sticks, Crawfords' Wood, near Crawfordsville, Aug. 27, 1917, Fink & Fuson 272 (MU).

Certain determination of this species, as is pointed out in the key to species of Diatrypella, depends almost entirely on ascus measurements. Asci of *D. prominens* (Howe) E. & E. are constantly less than 60 microns in length, the shortest ones to be found among the species reported for Indiana.

4. *Diatrypella quercina* (Persoon) Nitschke

Sphaeria quercina Persoon, Syn. meth. fung. 24. 1801.

Diatrype quercina Fries, Summa Veg. Scand. 385. 1849.

Diatrypella Rousselii Cesati & DeNotaris, Schema Sfer. Ital. 32. 1863.

Diatrypella quercina (Persoon) Nitschke, Pyr. Germ. 71. 1867.

Stromata erumpent, surrounded by the substellate-cleft, adherent epidermis, pulvinate, orbicular or angular, rugose, thick; disk plano-convex, becoming black, mostly solitary but sometimes 2-3 confluent, 2-4 mm. in diameter. Perithecia 2-15 in a stroma, in a single or double layer, ovoid or subangular from compression, 0.5-0.75 mm. in diameter, attenuated into rather long necks rising through the grayish-white substance of the stroma with their conic-hemispherical, quadrisulcate ostiola distinctly erumpent. Asci clavate-fusoid long-stipitate, sp. p. 80-100 x 9-10 microns. Ascospores numerous, allantoid, yellowish, strongly curved, 8-12 x 2-3 microns.

Specimens examined:

Putnam Co.: on dead oak, near Big-Four Springs, Greencastle, May 27, 1908, Daisy G. Lewis (DPU).

The relatively large asci of *D. quercina* (Pers.) Nke. (sp. p. 80-100 microns in length) readily distinguish it from other members of the genus. The multi-spored asci are easily made out, thus precluding the possibility of confusion of the species with members of the genus Diatrype.

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Indiana Plant Distribution Records, IX. 1948

Genera are listed in the order used in Deam's "Flora" and species are given in alphabetical order within the genera. Symbols following the county indicate the herbaria in which confirming specimens have been deposited. Entities new for the state are given in bold face followed by literature references and name of collector. Cases of doubt whether a taxionomic entity, newly found within the state, will become a part of the state flora are preceded by an asterisk.

The specimens listed below have been collected by the following collectors: Ball State Teachers College (BS): Mrs. Marian Rector; Butler University (B): Ray C. Friesner, Fred Loew, John E. Potzger, William Reynolds, Jack Secor, Frances Shockley, Homer H. Smith and Floyd A. Swink; Deam Herbarium (D): Charles C. Deam, Ray C. Friesner, and Floyd A. Swink; Gray Herbarium (G): Edwin D. Hull; Huntington College (Hu): Fred Loew; Indiana University (IU): Medford E. Campbell, Charles Heiser, and Arthur L. Reed; Wabash College (W): Dr. A. Clapp.

The committee maintains a card file showing published distribution of each species within the state. Botanical workers needing such information may obtain distribution maps of any species recorded in the Flora, or subsequently added in these reports, by requesting same from the secretary of this committee.

SPECIES

Botrychium dissectum v. *obliquum*, Clay (B). *Osmunda claytoniana*, Delaware (BS). *O. regalis* v. *spectabilis*, Clay (B). *Cystopteris fragilis* v. *protrusa*, Franklin (B). *Dryopteris intermedia*, Morgan (B). *D. thelypteris* v. *pubescens*, Jennings (B). *Polystichum acrostichoides*, Delaware (BS). *Athyrium angustum*, Delaware (BS). *A. asplenioides*, Delaware (BS), Green (B), Owen (B). *Equisetum arvense*, Delaware (BS).

Juniperus virginiana v. *crebra*, Greene (B), Huntington (Hu). *Typha angustifolia*, Green (B). *T. latifolia*, Greene (B). *Sagittaria latifolia*, Henry (D). *Bromus purgans* f. *laevivaginata*, Pulaski (D), Wayne (D). *Eragrostis hypnoides*, Pulaski (D). *E. pectinacea*, Adams (D). *Hystrix patula* v. *bigeloviana*, Wayne (D). *Muhlenbergia mexicana*, Adams (D). *M. sobolifera*, Grant (D). *Sporobolus cryptandrus*, Cass (B). *Brachyelytrum erectum*, Wayne (D). *Panicum dichotomiflorum*, Adams (D). *Setaria verticillata*, Rush (D). *Cyperus strigosus*, Huntington (Hu). *Eleocharis acicularis* v. *typica*, Pulaski (D). *E. compressa*, Greene (B), Howard (B), Newton (B). *E. obtusa*, Huntington (Hu). *Carex comosa*, Huntington (Hu). *C. grayii*, Wayne (D). *C. squarrosa*, Huntington (Hu).

Acorus calamus, Huntington (Hu). *Symplocarpus foetidus,* Delaware (BS). *Arisaema atrorubens* f. *viride,* Delaware (BS), Vermillion (B). *A. a.* f. *zebrinum,* Delaware (BS). *Commelina communis,* Greene (B): *Tradescantia virginiana,* Adams (BS). *Luzula multiflora* v. *bulbosa,* Vermillion (B). *Allium candense,* Franklin (B), Henry (BS). *A. vineale,* Hamilton (B), Vermillion (B). *Polygonatum commutatum* Vermillion (B). *Smilacina racemosa* v. *cylindrata,* Henry (B). *Medeola virginiana,* Greene (B). *Trillium flexipes,* Greene (B). *T. grandiflorum,* Delaware (BS). *T. sessile* f. *luteum,* Delaware (BS), Henry (BS). *Dioscorea quaternata,* Franklin (B). *Sisyrinchium albidum,* Huntington (Hu). *S. angustifolium (S. graminoides* of Flora), Delaware (BS). *Cypripedium candidum,* Randolph (B). *Habenaria peramoena,* Greene (B). *Spiranthes cernua,* Pulaski (D).

Salix pedicellaris v. *hypoglauca,* Steuben (D). *S. rigida,* Huntington (B). *Populus heterophylla,* Clay (B), Greene (B). *Juglans nigra,* Greene (B), Rush (D). *Carya ovalis* v. *obovalis,* Huntington (B). *Quercus bicolor,* Clay (B). *Q. coccinea* v. *tuberculata,* Martin (B). *Q. muhlenbergii,* Miami (D). *Q. palustris,* Jennings (B). *Ulmus thomasi,* Rush (D). *Urtica dioica* v. *procera,* Adams (D), Wabash (B). *Laportea canadensis,* Wabash (B). *Asarum canadense,* Delaware (BS). *Rumex acetosella,* Delaware (BS). *R. verticillatus,* Huntington (Hu). *Polygonum aviculare,* Huntington (Hu). *P. buxiforme,* Putnam (B). *P. coccineum,* Pulaski (D). *P. hydropiperoides,* Clay (B), Huntington (Hu). *P. neglectum,* Greene (B). *P. pennsylvanicum* v. *laevigatum,* Adams (D). *P. p.* v. *l.* f. *pallescens,* Huntington (B), Wabash (B). *P. persicaria,* Greene (B). *P. punctatum,* Greene (B), Wabash (B). *P. scandens,* Henry (B). *Parietaria pennsylvanica,* Rush (D)

Chenopodium ambrosioides ssp. *eu-ambrosioides* v. *typica,* Wabash (B). *Atriplex patula,* Huntington (Hu). *Amaranthus albus,* Monroe (IU). *A. graecizans,* Monroe (IU). *A. hybridus,* Adams (D), Monroe (IU). *A. spinosus,* Greene (B), Henry (D). *Acnida altissima,* Huntington (B). *Mollugo verticillata,* Clay (B). *Oxybaphus nyctogineus,* Pulaski (D). *Stellaria longifolia,* Delaware (BS). *S. media,* Delaware (BS). *Cerastium vulgatum* v. *hirsutum,* Delaware (BS). *Arenaria serpyllifolia,* Delaware (BS), Vermillion (B). *Paronychia fastigiata,* Greene (B). *Lychnis alba,* Monroe (IU). *Dianthus armeria,* Monroe (IU). *Caltha palustris,* Boone (B). *Isophyrum biternatum,* Delaware (BS). *Ranunculus abortivus,* Greene (B). Montgomery (B), Owen (B). *R. micranthus,* Franklin (B). *R. sceleratus,* Jay (BS).

Podophyllum peltatum, Delaware (BS). **P. peltatum** f. **deamii** Raymond, Rhodora, 50: 18. 1948. Harrison (D). Collected by Charles C. Deam. *Berberis vulgaris,* Henry (D). *Asimina triloba,* Greene (B). *Corydalis flavula,* Huntington (B, Hu). *Lepidium campestre,* Greene (B). *Lepidium virginicum* v. *typicum,* Greene (B). *Thlaspi arvense,* Delaware (BS). *Sisymbrium altissimum,* Huntington (Hu). *Brassica kaber* v. *pinnatifida,* Wells (BS). *Barbarea vulgaris* v. *arcuata,* Delaware (BS), Greene (B). *Rorippa islandica* v. *microcarpa,* Greene (B).

Nasturtium officinale, Delaware (BS). *Armoracea rusticana,* Delaware (BS). *Cardamine bulbosa,* Clinton (B). *Capsella bursa-pastoris,* Greene (B). *Descurainea sophia,* Delaware (BS). *Arabis glabra,* Henry (BS). *A. hirsuta* v. *adpressipilis,* Delaware (BS). *A. laevigata,* Adams (BS), Delaware (BS). *Hesperis matronalis,* Delaware (BS).

Sedum ternatum, Delaware (BS). *Rubus occidentalis,* Delaware (BS). *Potentilla monspeliensis,* Greene (B). *P. recta,* Delaware (BS). *Geum laciniatum* v. *trichocarpum,* Greene (B). *G. vernum,* Clinton (B). *Agrimonia parviflora,* Steuben (D). *A rostellata,* Greene (B). *Baptisia leucantha,* Greene (B). *Medicago lupulina,* Greene (B). *Melilotus alba,* Greene (B). *Trifolium hybridum,* Huntington (Hu). *T. h.* v. *elegans,* Delaware (BS). *T. pratense,* Huntington (Hu). *T. repens,* Huntington (Hu). *Robinia pseudoacaccia,* Huntington (Hu). *Lespedeza capitata* v. *velutina,* Newton (B), White (B). *Amphicarpa bracteata,* Owen (B). *Apios americana,* Greene (B), Pulaski (B). *Strophostyles liosperma,* Greene (B). *Geranium carolinianum,* Delaware (BS), Vermillion (B). *G. pusillum,* Huntington (Hu). *Oxalis europaea,* Delaware (BS). **O. e.** v. **bushii** (Small Wieg. Rhodora 27: 136. 1925.) Greene (B). Collected by R. C. Friesner. *O. e.* v. *b.* f. *subglabrata,* Greene (B). *O. e.* v. *b.* f. *vestita,* Greene (B). *O stricta,* Delaware (BS), Grant (BS). *O. violacea* v. *trichophora,* Montgomery (B). *Linum medium* v. *texanum,* Greene (B). *Polygala ambigua,* Brown (IU). *Euphorbia commutata,* Bartholomew (B), Delaware (BS).

Staphylea trifolia, Franklin (B). *Vitis palmata,* Vermillion (B). *Hibiscus trionum,* Adams (D). *Hypericum sphaerocarpum,* Greene (B). *H. tubulosum,* Harrison (W). *Viola pallens,* Howard (B). *V. striata,* Bartholomew (B). *V. triloba,* Ripley (B). *Decodon verticillatus,* Pulaski (D). *Oenothera laciniata,* Greene (B). *Myriophyllum heterophyllum,* Kosciusko (B). *Proserpinaca palustris* v. *crebra,* Pulaski (D).

Sanicula canadensis v. *typica,* Greene (B), Henry (B). *Osmorhiza claytoni,* Jennings (B). *Erigenia bulbosa,* Bartholomew (B). *Taenidia integerrima,* Adams (BS). *Thaspium barbinode,* Delaware (BS). *T. trifoliatum* v. *flavum,* Morgan (B). *Pastinaca sativa,* Delaware (BS). *Nyssa sylvatica* v. *caroliniana,* Vermillion (B). *Monotropa uniflora,* Pulaski (D). *Samolus parviflorus,* Brown (IU). *Lysimachia lanceolata,* Noble (B). *Dodecatheon meadia,* Huntington, (Hu), Ripley (B). *Fraxinus americana,* Greene (B). *F. biltmoreana,* Clay (B), Greene (B). *F. lanceolata,* Greene (B). *F. quadrangulata,* Rush (D). *F. tomentosa,* Clay (B). *Gentiana andrewsii,* Clay (B). *G. procera,* Carroll (B).

Apocynum cannabinum v. *glaberrimum,* Greene (B), Morgan (B). *Asclepias incarnata,* Brown (IU). *A sullivantii,* Greene (B). *A syriaca,* Greene (B). *A. tuberosa* ssp. *interior,* Greene (B). *Cuscuta campestris,* Henry (B, DP). Jennings (B), Wabash (B, DP). *C. glomerata,* Greene (B, DP). *C. gronovii,* Huntington (Hu, B), Owen (B). *Convolvulus sepium* v. *americanus,* Greene (B). *Phlox glaberrima,* Greene (B). *Collomia linearis,* Lake (D). *Hydrophyllum appendiculatum,* Rush (D).

Phacelia purshii, Delaware (BS). *Cynoglossum virginianum,* Morgan (B). *Myosotis macrosperma,* Wells (BS). *M. scorpioides,* Wabash (B). *Mertensia virginica,* Delaware (BS). *Lithospermum arvense,* Bartholomew (B). *Verbent hastata,* Henry (D,B). *X. V. rydbergii,* Pulaski (B) *V. stricta,* Pulaski (B). *V. urticaefolia* v. *leiocarpa,* Huntington (B), Owen (B). *Teucrium canadense* v. *virginicum,* Greene (B), Steuben (D). *T. occidentale* v. *boreale,* Greene (B). *Scutellaria lateriflora,* Greene (B), Pulaski (D). *S. parvula* v. *leonardi,* Greene (B). *Agastache nepetoides,* Grant (D). *Glecoma hederacea* v. *parviflora,* Delaware (BS). *Physostegia speciosa,* Wabash (B). *Lamium purpureum,* Monroe (IU). *Stachys tenuifolia* v. *hispida,* Greene (B). *Monarda fistulosa* v. *mollis,* Greene (B). *Pycnanthemum incanum,* Greene (B). *P. flexuosum,* Henry (B). *P. virginianum,* Pulaski (D). *Lycopus americanus,* Greene (B). *L. rubellus,* Greene (B). *L. uniflorus,* Clay (B). *Perilla frutescens* v. *crispa,* Wabash. (B). *Lycium halimifolium,* Monroe (IU). *Physalis heterophylla,* Franklin (B), Owen (B). *Solanum nigrum,* Pulaski (D). *Datura stramonium,* Greene (B). *Collinsia verna,* Delaware (BS), Ripley (B). *Chelone obliqua* v. *speciosa,* Greene (B). **Penstemon gracilis** Nutt. Rhodora 49:256. 1947. Lake (G). Collected by Edwin D. Hull. *Mimulus ringens,* Greene (B). *Leucospora multifida,* Henry (B). *Gerardia purpurea,* Carroll (B). *G. tenuifolia* v. *typica,* Clay (B).

Plantago lanceolata, Delaware (B), Greene (B). *P. rugelii,* De Kalb (D). *Houstonia longifolia,* Delaware (BS). *Diodia teres* v. *setifolia,* Monroe (IU). *Galium tinctorium (G. trifidum* ssp. *tinctorium),* Brown (IU). *Triosteum aurantiacum,* Clinton (B). *Lonicera dioica,* Scott (B). *Valeriana pauciflora,* Delaware (BS). *Viburnum dentatum* v. *deamii,* Greene (B). *Sicyos augulatus,* Morgan (B). *Campanula rapunculoides,* Lake (G). Rhodora 47:404. *C. uliginosa,* White (B). *Lobelia spicata* v. *leptostachya,* Greene (B).

Vernonia fasciculata, Cass (B), Pulaski (B). *Eupatorium altissimum,* Miami (D). *E. maculatum,* Pulaski (D). *E. purpureum,* Pulaski (D). *E. rugosum,* Pulaski (D). *E. serotinum,* Owen (B). *Liatris spicata,* Greene (B). *Solidago canadensis* v. *gilvocanescens,* Huntington (B). *S. latifolia,* Owen (B). *S. rugosa* v. *typica,* Henry (B). *Aster cordifolius,* Cass (B). *A ericoides,* Pulaski (D). *A. interior,* Clay (B), Owen (B), Wabash (B). *A. lucidulus,* Carroll (B). *A. novae-angliae,* Adams (D). *A. praealtus,* Lake (B). *A. p.* v. *angustior,* Huntington (B). *Erigeron annus,* Franklin (B), Greene (B). *E. strigosus,* Greene (B). *Antennaria fallax,* Delaware (BS). *A neglecta,* Marion (B). *A. neodioica,* Delaware (BS). *Silphium laciniatum* v. *robinsonii,* Tipton (B). *S. perfoliatum,* Wabash, (B). **S. terebinthinaceum v. pinnatifidum** (Ell.) Gray, Gray Man. 7 ed. p. 825. Pulaski (B, D). Collected by Charles C. Deam and R. C. Friesner. *Ambrosia elatior,* Greene (B), Huntington (B). *Rudbeckia deamii,* Greene (B). *R. hirta,* Delaware (BS). *R. laciniata,* Henry (D). *R. sullivantii,* Greene (B).

Helianthus annuus, Monroe (IU). *H. divaricatus,* Cass (B), Monroe (IU). *H. giganteus,* Marion (B). *H. hirsutus,* Pulaski (D). *H. stru-*

mosus, Huntington (B). *Bidens discoidea,* Pulaski (D). *Galinsoga ciliata,* Greene (B). *Helenium autumnale* v. *parviflorum,* Huntington (B), Wabash (B). *Anthemis cotula,* Brown (IU), Greene (B). *Matricaria matricarioides,* Noble (B), Ripley (IU). *Chrysanthemum leucanthemum* v. *pinnatifidum,* Delaware (BS). *Senecio plattensis,* Montgomery (B). *Arctium minus,* Clay (B), Huntington (Hu). *Cirsium discolor,* Cass (B). *Tragopogon porrifolius,* Delaware (BS), Greene (B). *T. pratensis,* Delaware (BS). *Taraxacum palustre* v. *vulgare,* Greene (B). *Lactuca canadensis* v. *obovata,* Huntington (B). *L. c.* v. *typica,* Greene (B). *L. saligna,* Greene (B), Monroe (IU).

Additional Species Added to the Deam Herbarium

The following species previously reported in other herbaria have been added to the Deam herbarium since the last report.

Juniperus virginiana v. *crebra,* Miami. *Hordeum jubatum,* De Kalb. *Setaria viridis,* Rush. *Sorghastrum nutans,* Henry. *Lilium michiganense,* Wayne. *Quercus alba,* Pulaski. *Amaranthus spinosus,* Wells, *Caulophyllum thalictroides,* Rush. *Penthorum sedioides,* Pulaski. *Agrimonia parviflora,* Henry. *Epilobium coloratum,* Pulaski. *Desmodium sessilifolium,* Pulaski. *Thaspium barbinode,* Wayne. *Asclepias sullivantii,* Pulaski. *Viburnum dentatum* v. *deamii,* Henry. *Vernonia altissima,* Henry. *V. missurica,* Pulaski. *Eupatorium fistulosum,* Henry. *E. perfoliatum,* Henry. *Solidago nemoralis* v. *decemflora,* Pulaski. *Rudbeckia triloba,* Jefferson. *Erechtites hieracifolia,* Pulaski. *Cirsium muticum,* Henry.

Deletions

The following specimen reported in Records IV should be deleted: *Rhamnus lanceolata,* Jennings (B).

State Flora Committee:

Charles C. Deam, *Chairman*
T. G. Yuncker
Ray C. Friesner, *Secretary.*

CHEMISTRY

Chairman: E. St. Clair Gantz, Purdue University

William G. Kessel, Indiana State Teachers College, was elected chairman for 1949.

ABSTRACTS

Should Inorganic Chemistry be Restored to the Undergraduate Curriculum? Charles L. Rulfs, Herbert C. Brown, E. St. Clair Gantz, Purdue University.—In effect, inorganic chemistry is no longer being taught in the usual undergraduate curriculum. The time and attention which were once devoted to the subject in the first and second year courses in chemistry are now primarily devoted to physical chemical topics. As a result, the average chemistry major is ignorant of any but the most rudimentary facts of inorganic chemistry and is greatly handicapped as a result. Because of the large proportion of non-chemistry majors in the present General Chemistry and Qualitative Analysis courses, it is probably undesirable to attempt to shift the present emphasis on chemical theory back to descriptive inorganic chemistry. Instead, it is believed that the present deficiency can best be remedied by introducing in the junior or senior year a new course in inorganic chemistry. Such a course, required of all chemistry majors, would acquaint the students with the subject matter of inorganic chemistry much as the present organic course presents the subject matter of organic chemistry. Although others may prefer a different solution, some means must soon be found to remedy the present glaring deficiency in the training of chemistry majors.

More About the Composition of Turquoise, Frank B. Wade, Head, Dept. of Chemistry, Shortridge High School, Indianapolis, Ind.—Further study of turquoise shows that it contains Carbon. We had previously shown that it contained nitrogen. We then suspected that the color was due to $Cu(NH_3)_4^{++}$ ion. We now suspect that the colorant may be $CH_3NH_2Cu^{++}$ ion since combustion tests show that the amount of carbon agrees well with the amount of nitrogen if CH_3 NH_2 Cu^{++} ion is the colorant.

Table of analyses made by the Chem IV class at Shortridge High School under the direction of Walter C. Geisler follows:

Sample	CO_2	(calc.) Carbon	N equiv. (calc.)	NH_3 (calc.)	NH_3 (found)
1	.365	.099	.115	.139	.16
2	.241	.065	.075	.091	.10
3	.237	.064	.074	.089	.10
4	.296	.077	.089	.108	.12
5	.312	.085	.096	.119	.13

Determination of Fluorine in Waters, I. A Rapid Direct Method, II. A Rapid Distillation Method. W. E. THRUN, Valparaiso, University.—A dilute solution of the aluminum lake of Eriochromecyanine buffered at pH 5.4-5.6 is the reagent used with 5 to 10 ml. samples of water. The fluoride ion destroys the color. Comparisons with standards are made 10-15 minutes later.

The distillation is performed over sulfuric acid with a 100 ml. sample plus 10 ml. of distilled water until 90 ml. have been collected. The distillate is cooled, buffered to pH 5.4-5.6, made up to 100 ml., and the fluorine determined as above. The distillation is performed by creating a high turbulence with air and a high temperature.

Since the agreement between the results by the direct method and those obtained on the distillate is excellent and since the aluminum ion deepens the color and the silicate ion destroys it, a very reasonable assumption should be that the alumina and silicate in natural waters are tied up with each other and that the fluorine exists as ions.

The Separation of Isomers of Nickel (II) Complexes by Chromatographic Adsorption. E. ST. CLAIR GANTZ and BENEDICT L. VONDRA, Purdue University.—Nickel complexes of glycine benzeneazo-β naphthol, methylglyoxime, salicylaldoxime, salicylaldehyde, benzoylacetone, and salicylaldimine were prepared. The complex with methylglyoxime is known to exist in isomeric forms. This information is lacking with regard to the other compounds. It was hoped that an adsorbent or adsorbents and eluting reagents might be discovered by which isomeric forms could be isolated. No resolutions were obtained using a variety of adsorbents including alumina, magnesium oxide, silica gel, barium sulfate, calcium sulfate, and talc. A large number of solvents were also used in an effort to obtain a separation of isomers on the various columns studied.

Studies of Lithium Hydride[2]

D. W. PEARCE,[1] R. E. BURNS,[1] and E. ST. CLAIR GANTZ,
Purdue University

Introduction

The negative character of the hydrogen in lithium hydride was first postulated by Lewis (1) and later by Nernst (2). Their predictions were substantiated by Moers (3) and Peter (4) who were able to show that, in the electrolysis of lithium hydride, hydrogen is liberated at the anode. The fact that the negative hydrogen present in lithium hydride and other salt-like hydrides is a powerful reducing agent is well known (5). However, very little specific information relative to the reducing properties of lithium hydride is available in the literature. These investigations were undertaken in the hope that additional information concerning the behavior of lithium hydride toward inorganic compounds, particularly those of elements of the transition groups might be gained. It was also desired to find a reaction medium in which lithium hydride is soluble and stable and to develop the necessary techniques for studying reactions with lithium hydride in such a medium.

Two different types of reactions were studied. In the first case, solid-solid reactions involving mixtures of lithium hydride with various chlorides and oxides were investigated. It was found that lithium hydride is soluble without decomposition in the fused lithium chloride-potassium chloride eutectic (40 mole per cent potassium chloride) which melts at 350°C. The second series of reactions studied was between suspensions of certain oxides in this melt and lithium hydride dissolved in the melt.

Experimental

The lithium hydride used in these investigations was obtained from the Fairmount Chemical Company of Newark, New Jersey. For use in these studies it was necessary to grind the hydride to a fineness of about 100 mesh. A solenoid-operated vacuum grinder was used for this purpose to prevent the reaction of the hydride with moisture in the air during the grinding process.

All of the reactions studied were performed in an apparatus similar to that shown in Figure 1. The reaction vessel consisted of a stainless steel crucible. A large thick-walled test tube heated by an electric muffle formed the reaction vessel. The type of manometer used depended

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[1] Now at Hanford Chemical Works, Richland, Washington.

[2] This paper contains material from thesis of R. E. Burns presented to faculty of Purdue University in partial fulfillment of requirements of Ph.D. Feb. 1948.

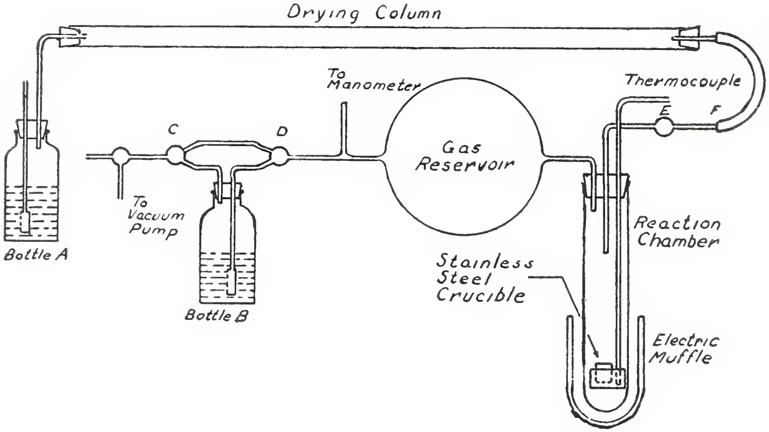

Figure 2 Apparatus for Studying Reactions

upon the reaction being studied. A Wegner distillation pump capable of reducing the pressure to 0.01 mm. Hg. was used to evacuate the apparatus. Gases admitted to the apparatus passed through Bottle (A), containing a strong potassium hydroxide solution, and the drying column which was packed with Drierite. Carbon dioxide and water were thus removed from the admitted gases. Bottle (B) contained a standardized sodium hydroxide solution and the two three-way stopcocks (C) and (D) provided a means whereby the gaseous products generated during a reaction could be pumped through the standard base solution.

(I) *Solid-Solid Reactions of Lithium Hydride with Alkali Chlorides.*—A series of four reactions was studied in which mixtures of solid lithium hydride with, successively, the solid chlorides of sodium, potassium, rubidium, and cesium were heated under reduced pressure. For these reactions a Zimmerli manometer was attached to the apparatus to permit the determination of small departures from zero pressure. The reactions were all performed in essentially the same manner. A small, known quantity of ground lithium hydride was placed in the stainless steel crucible and heated, under vacuum, to a temperature of about 550°C. for one-half hour to remove any traces of moisture. When cooled, a weighed quantity of the alkali chloride was added and mixed intimately with the lithium hydride. The alkali chlorides had been previously ground and then dried at temperatures slightly below their melting points. The mixture was then heated to 300°C. under vacuum (continuous pumping). At that temperature the system was closed to permit any gas generated by the reaction to be retained in the apparatus.

In each case, at temperatures around 500°C. there occurred a sudden increase in pressure and a mirror-like deposit formed on the walls of the reaction chamber above the heated zone. The reaction usually continued for about thirty minutes. When the apparatus had cooled to room temperature, the pressure was noted and the amount of gas produced was calculated by use of the gas law.

Air was then admitted to the apparatus through Bottle (A). Bottle (B) contained a standard sodium hydroxide solution. The gases in the apparatus were then pumped through Bottle (B) and the resulting solution was titrated with standard hydrochloric acid solution.

The distilled material in the mirror-like deposit and the residue remaining in the crucible were examined separately for lithium and the other alkali metal concerned by standard analytical procedures. The data obtained in these experiments are shown in Table 1. It is to be noted that in no case was any hydrogen chloride produced. Also it is of interest that reduction of the alkali metal chloride to the metal is nearly complete in each case and the quantity of gas produced corresponds roughly to one-half mole of hydrogen per mole of alkali chloride reduced. In view of these observations it was concluded that the reactions were probably of the type

$$2\,\mathrm{LiH} + 2\,\mathrm{MCl} \rightarrow 2\,\mathrm{LiCl} + 2\,\overline{\mathrm{M}} + \mathrm{H_2}. \qquad \text{(A)}$$

These reactions were repeated using metallic lithium in place of the lithium hydride. The alkali metal chlorides were reduced to the metals in these reactions in the same manner and at about the same temperature as when lithium hydride was used. Consequently, one cannot be certain whether a reaction mechanism as illustrated by the following equations is responsible for the reductions observed when lithium hydride is used rather than that represented by Equation (A).

$$2\,\mathrm{LiH} \rightarrow 2\,\mathrm{Li} + \overline{\mathrm{H_2}}$$

$$2\,\mathrm{Li} + 2\,\mathrm{MCl} \rightarrow 2\,\overline{\mathrm{M}} + \mathrm{LiCl} \qquad \text{(B)}$$

The same relative quantity of gas would be produced in either case. However, the pressures attained in the reactions involving lithium hydride ranged from 16 to 26 mm. Hg. while the decomposition pressure of lithium hydride is given as 0.07 mm. Hg. at 500°C. Hence, for the reaction as represented by (B) to continue, the lithium hydride would have to decompose against a pressure of hydrogen much in excess of its decomposition pressure at the reaction temperature.

(II) *Solid-Solid Reactions of Lithium Hydride With Oxides of Groups IV and V.*—These reactions were performed in essentially the same manner as those involving the alkali halides except that the preheating of the lithium hydride to remove moisture was not done and the gases evolved were not checked for the presence of acidic constituents. No products distilled out of the reaction vessel in these reactions. Pressures and temperatures were noted and the quantity of gas evolved was calculated, although no coordination between the quantity of gas evolved and the degree of reduction attained was found. Since the decomposition pressure of lithium hydride is about 15 mm. Hg. at the temperatures reached in these experiments (ca. 600°C.) it is

TABLE I. Reaction of Lithium Hydride with Alkali Chlorides.

Alkali Chloride	m. Moles LiH	m. Moles Alkali Chloride	Mole Ratio LiH/MCl	m. Moles Gas Per m. Mole MCl	m. eq. HCl formed	MCl Left in Residue	Temp. of Initial React.	Max. Temp.
NaCl	9.72	1.22	7.96	0.50	0	absent	500	520
KCl	9.08	1.13	8.01	0.51	0	absent	490	517
RbCl	13.0	1.58	8.22	0.53	0	ca. 5 mg. present	472	530
CsCl	6.95	0.881	7.88	0.58	0	trace	480	530

TABLE 2. Reactions of Lithium Hydride with Group IV and Group V Oxides.

Oxide	m. Moles Oxide	LiH m. Moles	Mole Ratio LiH Oxide	Max. Temp. °C.	m. Moles Gas Per m. Mole Oxide	Color of Product	Possible Formula Product
ThO_2	1.825	7.86	4.31	600	0.53	White	ThO_2
ZrO_2	1.62	6.71	4.13	610	0.70	Black	Zr, (ZrO, Zr_2O_3)
TiO_2	1.99	12.32	6.2	600	0.715	Black	Ti_2O_3
SiO_2	2.675	10.56	3.95	600	1.33	Black	Si
GeO_2	1.19	5.97	5.02	610	1.79	Black	GeO
Cb_2O_5	0.469	3.95	8.43	605	3.33	Black	Cb_2O_3, CbO_2

entirely possible that the decomposition of the hydride produced the major portion of the gas evolved. The data obtained for the solid-solid reactions between lithium hydride and thorium dioxide, zirconium dioxide, titanium dioxide, silicon dioxide, germanium dioxide and columbium pentoxide are given in Table 2.

The determination of the composition of the products of these reactions was difficult because of the instability of these elements in their lower oxidation states. The reaction product was, in each case, treated with water to remove the excess lithium hydride and any lithium oxide or metallic lithium formed in the reaction. The solutions were filtered and an attempt was made in each case to identify the residue by solubility tests. The probable formulas of the reduction products are given in Table 2.

(III) *Reactions of Lithium Hydride in a Lithium Chloride—Potassium Chloride Melt.*—In performing these reactions the apparatus shown in Figure 1 was used. An open J-tube manometer was used for pressure measurement since these reactions were studied under an atmosphere of helium at near atmospheric pressure. The following procedure was followed for all of the reactions studied. About one gram of lithium chloride was placed in a weighed stainless steel crucible and heated for one hour under vacuum (continuous pumping) and at a temperature of about 550°C. When cool, the crucible was weighed and the proper amount of potassium chloride previously dried by heating, was added to produce the eutectic. This mixture was heated under vacuum to a temperature of 300°C. Helium was then admitted through Bottle (B) to bring the apparatus to atmospheric pressure. Heating was continued until the mixture had fused completely. When again cool, a weighed amount of ground lithium hydride was added and the mixture was heated until fusion occured and the lithium hydride dissolved in the melt following the same procedure as when the potassium chloride was added.

When the apparatus was again cool, a weighed amount of the compound to be reacted with the lithium hydride was added. The mixture was then heated under vacuum to a temperature of 300°C. Helium was then admitted through Bottle (B) and the heating was continued. At some definite temperature, usually 345°C., the apparatus was allowed to come to atmospheric pressure. The system was then closed off and heating was continued until fusion occurred. In each case studied, a rapid reaction occurred immediately after fusion of the mixture. Heating was continued until the reaction was complete as indicated by a constant pressure. As the apparatus cooled, the pressure in the apparatus was noted when the temperature reached that at which the system was closed during heating. The pressure was again noted when the apparatus had cooled to room temperature. The atmospheric pressure was also noted. From the pressure and temperature data taken, the quantity of gas generated in the reaction could be calculated roughly. The gases in the apparatus were pumped through a standard sodium hydroxide solution in Bottle (B) and the resulting solution was titrated with standard hydrochloric acid solution.

TABLE 3. Reactions of Ta_2O_5, Cb_2O_5, V_2O_5, and Eu_2O_5 in a KCl-LiCl Melt.

Oxide	Run	m. Moles Oxide	m. Moles LiH	Mole Ratio $\frac{\text{LiH}}{\text{Oxide}}$	$\frac{\text{m. Moles Gas}}{\text{m. Moles Compound}}$	m. Moles Acidic Gas Formed	mg. Product	mg. Starting Material	Possible Formula Product
Ta_2O_5	A	0.786	12.64	16.1	1.86	0	345.0	348.2	TaO_2
Ta_2O_5	B	0.5797	9.13	15.5	1.97	0	264.6	256.8	$TaO_2 \bullet H_2O$
Cb_2O_5	A	1.364	21.8	16.0	2.52	0	334.0	363	Cb_2O_3
Cb_2O_5	B	.7304	11.41	15.6	. . .	.	147.7	194.4	Cb_2O_3
Cb_2O_5	C	.4419	6.98	15.8	2.50	0	106.0	117.6	Cb_2O_3
V_2O_5	A	1.902	24.7	13.0	3.86	0	215.2	346	VO
Eu_2O_3	B	0.435	6.4	14.9	1.5	0	133.3	152.9	Eu_2SO_4
Eu_2O_3	A	0.430	6.8	15.7	1.5	0	53.5	151.7	Eu_2SO_4

Treatment of the residues differed according to the reaction being studied. Table 3 presents the data obtained in the study of the reaction of lithium hydride with tantalum pentoxide, columbium pentoxide, vanadium pentoxide, and europium trioxide.

Summary

Lithium hydride reacts with sodium chloride, potassium chloride, rubidium chloride, and cesium chloride under reduced pressure and at temperatures around 500°C. In each case a gas (probably hydrogen) is evolved and the alkali metal other than lithium is distilled from the hot zone to the cooler parts of the reaction chamber. The results obtained indicate that the reaction is probably of the type

$$LiH + MCl \rightarrow LiCl + \overline{M} + H_2.$$

Many oxides of Group IV and Group V elements react with lithium hydride under reduced pressure and at temperatures around 500°C. The product of the reduction may be the element or oxides of the element in lower oxidation states. The experiments performed indicate that the following reductions occur under these conditions.

Thorium dioxide is not reduced.
Zirconium dioxide is reduced to the metallic state.
Titanium dioxide is reduced to the tervalent state.
Silicon dioxide is reduced to amorphous silicon.
Germanium dioxide is reduced at least to the bivalent state and perhaps to the metal.
Columbium pentoxide is reduced, possibly to the tervalent state.

The lithium chloride-potassium chloride eutectic, at its melting point, will dissolve lithium hydride. The resulting solution may be used as a reaction medium for the study of reactions of lithium hydride with solids not soluble in the eutectic. The reactions of the pentoxides of tantalum, columbium, and vanadium with lithium hydride in the eutectic were studied.

The identification of the products obtained in these reactions was difficult due to the instability of these elements in their lower oxidation states. The evidence obtained indicates that tantalum is reduced at least to the tervalent state and that vanadium is reduced to the bivalent state. The identification of these oxidation states was not rigorous and the results obtained are indicative only.

Europic oxide reacts with lithium hyride in a potassium chloride-lithium chloride melt. The europium may be recovered as europous sulfate by disintegrating the product obtained with dilute sulfuric acid. Quantitative recovery was not achieved.

This study is being continued in this laboratory.

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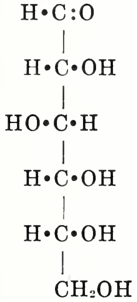
The Validity of the Emil Fischer Concept

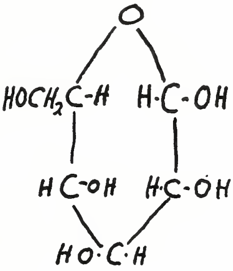
Ed F. Degering, Purdue University

The author has previously shown that (1) it is possible to make a straightforward transition from the aldehyde formula of a sugar to the pyranose or furanose formula and thus present a spatial concept of the molecule, and that (2) the configurational concept proposed by Emil Fischer visualizes the hydrogen atom and the hydroxyl group of an asymmetric grouping as *lying above the plane of the paper,* with the two other groups below the plane of the paper.

These two concepts enable one to make the transition from an aldehyde formula to a pyranose formula with ease, as indicated by:



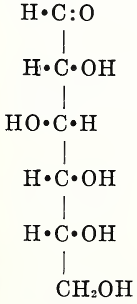
$$\begin{array}{c} \mathrm{H\cdot C{:}O} \\ | \\ \mathrm{H\cdot C\cdot OH} \\ | \\ \mathrm{HO\cdot C\cdot H} \\ | \\ \mathrm{H\cdot C\cdot OH} \\ | \\ \mathrm{H\cdot C\cdot OH} \\ | \\ \mathrm{CH_2OH} \end{array}$$



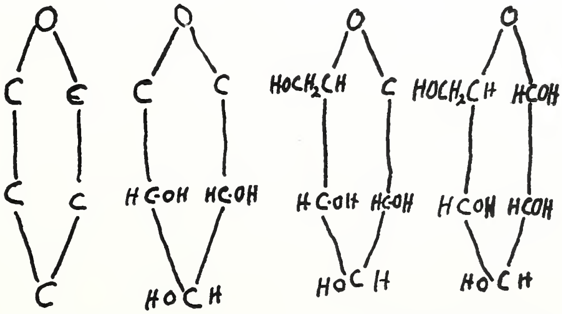
The open chain formula on the left, by ring formation and orientation so that the hetero atom is placed at the top and *the corresponding groups read left to right,* the same as in the aldehyde formula, becomes the pyranose formula shown at right.

D$^+$-glucose, aldehyde formula α-D$^+$-glucopyranose

The transition from an open chain aldose sugar formula to a pyranose formula, consists of (1) writing the open chain aldose formula, (2) writing a pyranose ring, with the oxygen atom oriented at the top and the carbon atoms numbered clockwise, (3) filling in the corresponding asymmetric groups so that they read *left to right in both formulas,* (4) placing the terminal HO•CH$_2$-group to the left with the H-atom to the right in the *D*-series or *vise versa* in the *L*-series, and (5) filling in the H- and OH-groups on carbon atom grouping No. 1 so as to give the *alpha-* or *beta*-form as desired. Diagramatically, the steps are:



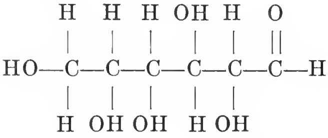
$$\begin{array}{c} \mathrm{H\cdot C{:}O} \\ | \\ \mathrm{H\cdot C\cdot OH} \\ | \\ \mathrm{HO\cdot C\cdot H} \\ | \\ \mathrm{H\cdot C\cdot OH} \\ | \\ \mathrm{H\cdot C\cdot OH} \\ | \\ \mathrm{CH_2OH} \end{array}$$



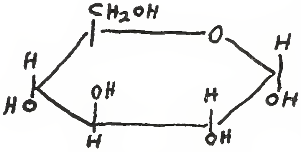
α-*D*-glucopyranose,
by Degering

Step No. 1 Step No. 2 Step No. 3 Step No. 4 Step No. 5

Even the beginning student in organic chemistry makes the transition with ease, whereas graduate students encounter extreme difficulty in making the transition from the open chain formula of α-D$^+$-glucose, for example, to the Haworth formula which is indicated below. The transition to the Haworth formula would be comparatively simple if the conventional method of writing the formula of D-glucose, for example, was as follows:



$$\begin{array}{ccccccccccccc} & & H & & H & & H & & OH & & H & & O \\ & & | & & | & & | & & | & & | & & \| \\ HO & — & C & — & C & — & C & — & C & — & C & — & C—H \\ & & | & & | & & | & & | & & | & & \\ & & H & & OH & & OH & & H & & OH & & \end{array}$$



α-*D*-glucopyranose,
by Haworth

In view of the fact, however, that the formulas of the open chain sugars are written vertically with the aldehyde group at the top, the transition to the Haworth formula becomes difficult. One should not discount the significant contribution which was made to the chemistry of the carbohydrates by the introduction of the ring or closed chain formulas by Haworth and Peat[3], nor should one be a slave to a concept that does not follow the accepted orientation of heterocyclic systems[5] nor permit of ready transition from the open chain system with which the student is most familiar to the closed chain, ring, or pyranose system.

At the same time, moreover, one is able to visualize the spatial arrangement of the atoms in the pyranose formula in that all of the groups lying to the *right* of a carbon atom are *below* the plane of the paper, whereas those lying to the *left* of the same carbon atom are *above* the plane of the paper. This may be indicated by making the proper lines heavy so as to give a perspective as well as a projection representation. This relative position of the H- and OH-groups with respect to the plane of the molecule may be confirmed readily by the construction of a tinker-toy model of the sugar concerned.

This concept seems the more significant now that Werner Kuhn has produced mathematical proof to vindicate the correctness of the Emil Fischer guess and thus increase the probability that the representation of α-D$^+$-glucopyranose as shown above is correct.

Actually, Kuhn established the absolute configuration of D$^-$-lactic acid, but by so doing he likewise established the absolute configuration of the simple sugars and all closely related compounds.

This contribution is so significant to the organic chemist that a few paragraphs, as translated by the author, are taken from theoretical dessertation by Werner Kuhn as it appeared in the Zeitschrift fur physikalische chemie in 1935, where it has since remained buried[4].

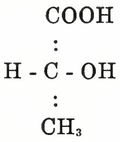
"A start for the theoretical calculation of the absolute configuration of lactic acid is made by determining by means of a simplified model, the sign of rotation of methyl ethyl carbinol, the steric relation of which to lactic acid is chemically defined.

"In the simplified model the methyl group, the active carbon atom, and the ethyl group are each represented by an isotropic resonator, whereby the charge of the ethyl group is assumed to be larger than either charge in the centers of gravity of the methyl group or of the active carbon atom. The reciprocal action of resonance occurring in these parts of the molecule is accurately calculated. For the alcoholic hydroxyl group we take respectively an isotropic and an anisotropic resonator of different directions of vibration as a starting point.

"For the calculation of the reciprocal action, the peripheral one caused by Van der Waal forces is neglected and consideration given to the reciprocal action due to direct chemical linkage.

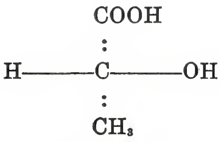
"If at first the optical vibration localized at the OH-absorption band of highest wave length is assumed to be anisotropic, one arrives at an optical activity of the second order. If the hydroxyl group is, however assumed to be isotropic, the rotation disappears in this order.

"By virtue of the Kerr-effect and the dispersion of light as observed on hydroxyl compounds, it is probable that in the carbonhydroxyl group the hydroxyl absorption band of highest wave length vibrates in the plane defined by the carbon, oxygen, and hydrogen. The result in this case is that the D—-lactic acid, which according to Emil Fischer is wherein the substituents connected by the *dotted line should be pictured behind the plane o fthe drawing.*



$$\begin{array}{c} \mathrm{COOH} \\ \vdots \\ \mathrm{H - C - OH} \\ \vdots \\ \mathrm{CH_3} \end{array}$$

Formula I



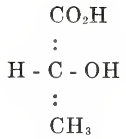
$$\begin{array}{c} \mathrm{COOH} \\ \vdots \\ \mathrm{H}\text{———}\mathrm{C}\text{———}\mathrm{OH} \\ \vdots \\ \mathrm{CH_3} \end{array}$$

Formula II

"It will be shown that vibrations which correspond to optical absorption bands of molecules should be considered anisotropic for theoretical as well as experimental reasons. Experimentally this is particularly evidenced by the Weigert-effect as observed on dye stuff molecules.

"Generally the optical vibrations of the absorption band of highest wave length of any given molecule takes place in that direction in which the polarizability (which is measured by the Kerr-effect and light dispersion) is at a maximum. From the Kerr-effect one can therefore conclude with good probability the direction of vibration which is characteristic for the absorption bands of highest wave length of the molecule."

Kuhn then proceeds to convince his reader by a thirty three page discussion, which is loaded with seven pages of mathematics. When one has traversed this long and weary way with Kuhn, he is convinced that Emil Fischer guessed right and the absolute configuration of D—-lactic acid is that shown at the right, in which the carbon atom at the asymmetric center lies in the plane of the paper, whereas the H- and OH-groups lie in front of the plane and the CO_2H- and CH_3-groups lie behind the plane of the page.



$$\begin{array}{c} CO_2H \\ : \\ H - C - OH \\ : \\ CH_3 \end{array}$$

D—-Lactic Acid

Having accepted the absolute configuration of lactic acid as that postulated by Emil Fischer, one is at once in a position to accept the absolute configuration of D+-glucose as represented by the α-D+-glucopyranose formulation at the outset of this article.

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3. Haworth, W. N., and S. Peat, **J. Chem. Soc., 1929,** 350.

4. Kuhn, Werner, Absolute Configuration of Lactic Acid, Zeitschrift fur physik. chem., (B) **31,** 33 (1935-36).

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The Structure of the Stereoisomeric Trithianes[1]

E. CAPAIGNE and WALTER M. BUDDE[2], Indiana University

When acetaldehyde is treated with hydrogen sulfide and hydrogen chloride, trithioacetaldehyde is formed, and originally (1) three different isomers; α, m.p. 101°; β; m.p. 125-6°, and γ; m.p. 81°; were isolated. It was possible to convert α into β by heating with iodine or acetyl chloride. Since the trithiane ring was assumed to be planar, only two isomers, cis-cis (I) and cis-trans (II) should exist. Suyver (2) demonstrated that a eutectic mixture of 60% α and 40% β isomer melts sharply at 75-76° and it was generally conceded that this is the explanation of the γ-isomer. It is still reported in the handbooks, however, and crops up as justification for different structures of the trithiane ring. In 1947, Schonberg and Barakat (3), disturbed by the ready interchange of α to β forms in a cylic system in which tautomerism is presumably impossible, proposed the following theory:

"The three carbon atoms and the three sulfur atoms in 1, 3, 5-trithiane molecules do not lie in one plane, but may be regarded as 'boat' and 'chair' structures, the interconversion then being readily explained. According to this explanation, the α- and β-forms of trithioacetaldehyde, for example, are either both cis- or both trans-forms; the isomeric change is due to a change of 'boat' into 'chair' structures, or vice versa. This new theory demands a greater number of isomers than have, so far, been isolated, but it is not thereby necessarily invalidated, for some isomers (γ-forms) have occasionally been described, which have been attributed *inter alia* to polymorphism or the occurrence of eutectic mixtures.

"In harmony with the new theory is the fact that the molecule of trithioformaldehyde in benzene solution and in the crystal contains not a planar but a puckered six-membered ring (4)."

Schonberg attributes the stability of the "boat" and "chair" forms to resonance.

Hinsberg (5) claimed to have isolated two forms of s-trithiane, but Fromm and Soffner (6) repeated the work and claimed that Hinsberg's second compound was actually a cyclic methylene sulfur compound, $(CH_2S)x$, where x was greater than 3. In 1929, the planar configuration of the s-trithiane ring was regarded as certain after Bell and Bennett (7) were able to separate all of the isomeric di- and tri-sulfoxides which would theoretically exist for a planar trimethylene trisulfide ring. Oxidation of s-trithiane with hydrogen peroxide in acetone yielded only one monoxide, A. Further oxidation with the calculated amount of hydrogen peroxide in acetic acid gave two disulfoxides, B and C, which could be separated by fractional crystallization from water. Since these oxides decompose at high temperatures without melting, their *non*-identity was demonstrated by their crystalline properties and solubility. Compound C, upon further oxidation yielded only one trisulfoxide, E. The

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[1] Abstracted from a thesis submitted by Walter M. Budde to the faculty of Indiana University in partial fulfillment of the requirements for the degree, Master of Arts, in the Department of Chemistry, June, 1947.

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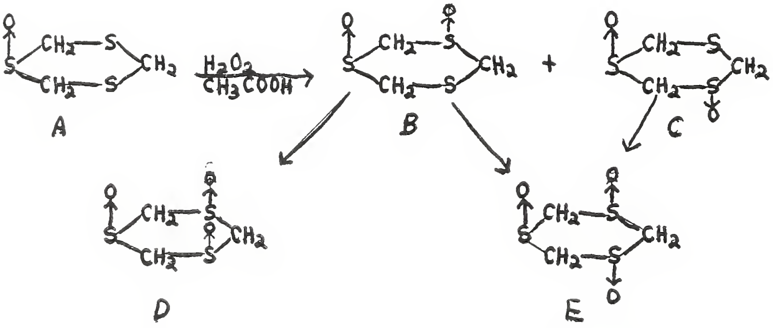
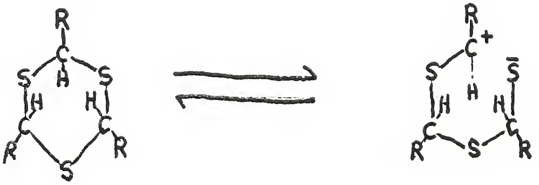


trans-configuration was therefore assigned to C, and *cis-trans* to E. This agrees with their solubilities and stabilities. Compound B upon further oxidation yielded two trisulfoxides, which were separated by fractional crystallization. One of these was identical with E, and the other, D, was assigned the *cis-cis* configuration. This would indicate that B has the *cis*-configuration.

It would seem that Schonberg's principle objection to *cis-cis* and *cis*-trans forms, the ready interconversion of α to β, could be explained by an actual tautomerism:



This is supported by some evidence obtained by Worner (8) and by our group.

Worner (8) studied isomers of the trithiobenzaldehyde series, and carefully developed methods of separating these isomers. In no case did he find more than two isomers formed in thirty different substituted benzaldehydes used. He did find that substituents exerted an influence on the products formed. Thus with certain substituents, both α and β forms could be isolated, while in other cases only one form was obtained. In some cases no trimer could be isolated. Results can be illustrated by a table.

TABLE I. Influence of Substituents on Formation of Thiobenzaldehyde Trimers.

Substituents	No. of Trimers Formed	Substituents	No. of Trimers Formed
none	2	2, 5—di—CH_3O—	2
4—CH_3O—	2	4—iso—C_3H_7	2
2—CH_3O	2	3—CH_3—	2
2—iso—C_4H_9O—	2	4—CH_3—	2
3, 4—di—CH_3O—	2	2—Br—	2
3, 4—CH_2O_2=	2	4—Br—	2
3—CH_3O—4—OH—	1	2, 4, 6—tri CH_3— (not checked carefully for 2 forms) (9)	1
2—HO—	1	3—NO_2—4—CH_3O	1
3—HO—	1	3—NO_2—4—iso—C_3H_7	1
4—HO—	1	3, 5—di NO_2—4—CH_3O—	1
2—C_6H_5COO—	1	2—CH_3—4—OH—5—iso—C_3H_7—	1 (a)
3—C_6H_5COO—	1	2—NO_2— (linear polymer)	0
3—CH_3O—	1 (?)	3—NO_2—	0 (ditto)
4—C_5H_5COO—	1	4—NO_2—	0 (ditto)
4—CH_3COO	1 (a)	4—CN	0 (ditto) (a)
3—CH_3O—4—C_6H_5COO—	1	4—COOH	0 (ditto) (a)
2, 5—di—OH—	1	4—$COOC_2H_5$	0 (ditto) (a)

(a) Prepared in this laboratory.

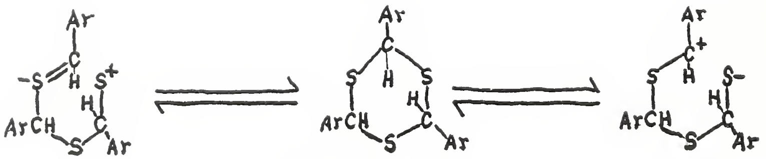
The following related compounds were also prepared:

Compound	No. of Trimers Formed
trithiocinnamaldehyde	2 forms
trithiofurfural	2 forms
trithio-2-thenaldehyde	2 forms
trithio-3-thenaldehyde	2 forms (a)
trithio-2-ethoxy-l-naphthaldehyde	1 form

(a) Prepared in this laboratory.

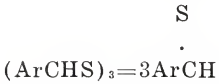
A theory which accounts for most of the cases is as follows:

Just as predicted by the laws of probability, an aryl thioaldehyde may trimerize to give both *cis-cis* and *cis-trans* forms of the puckered "chair" form. (No "boat" forms have been found (4).) In some cases, the resulting trimers are unstable due to the presence of certain labilizing groups on the aromatic ring. One form is always less stable than the other form. The influence of the substituent is due to its electron-attracting or electron-releasing effects.



Carbonium ion

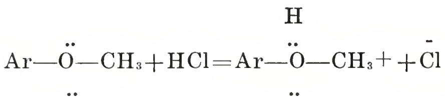
Thus a strong electron-releasing group Ar would allow carbonium ion formation and promote rearrangement of the α to the more stable β form. In the same way a strong electron-attracting Ar group would promote carbanion formation and have a similar effect. Polymer formation would be promoted in either case, and might predominate even over the β-trimer. The above dissociation can just as readily be written:



$$(ArCHS)_3 = 3Ar\overset{\overset{S}{\cdot}}{C}H$$

In this case the same reasoning applies, and dissociation is promoted by either electron-releasing or electron-attracting substituents on the aromatic ring. Thus extremely stable trimers were isolated in two forms, extremely unstable ones dissociate and form polymers, and intermediate stability is represented where only one form was isolated. The dissociation to monomer actually occurs, as shown by the fact that cryoscopic molecular weight determinations of the trimers which are obtained in only one form are usually low (see experimental values).

A glance at Table I shows that all of the aldehydes which yield only one trimer have strong electron-releasing groups, i.e. hydroxy or acyloxy or strong electron-attracting groups, i.e. nitro. Since acyloxy compounds yield only one isomer, it is surprising that methoxy compounds yield two, as methoxy groups are also strongly electron-releasing. It is possible that the hydrogen chloride used as a catalyst coordinates with the ether linkage, forming a weak electron-attracting group, thus permitting both α- and β-forms to be isolated (Note I).



$$Ar—\underset{\cdot\cdot}{\overset{\cdot\cdot}{O}}—CH_3 + HCl = Ar—\underset{\cdot\cdot}{\overset{\overset{H}{\cdot\cdot}}{O}}—CH_3{+} + \overset{-}{Cl}$$

This possibility is substantiated by the observation that when anhydrous zinc chloride is used as a catalyst with anisaldehyde, only the β-isomer of the trithial is obtained, along with linear polymer. A nitro group alone prevents trimerization, but 3-nitro-4-anisaldehyde has two counter-influences in the 3-nitro and 4-methoxy groups, the latter of which does not now coordinate due to lack of basicity (note ortho-nitroaniline).

The lack of a second isomer of *m*-methoxybenzaldehyde can only

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Note I. The coordination of hydrogen chloride with ethers is well known; thus anisaldehyde is quite soluble in concentrated HCl, but insoluble in water. Benzaldehyde is insoluble in concentrated HCl.

be explained on the basis of poor technique. It should be present, but may be difficult to isolate.

Compounds which yield two isomers, such as the halogen or alkyl-substituted benzaldehydes, have only weakly electron releasing groups present. It is probable that further work will show that two isomers of trithiomesitaldehyde do exist.

Since the nitro-group was the only strong electron-attracting group which had been incorporated in the molecule, we tried several other such groups with the same results. When p-cyanobenzaldehyde, p-carboxybenzaldehyde, and p-carbethoxybenzaldehyde were treated with hydrogen chloride and hydrogen sulfide in alcohol, only linear polymers of high molecular weight were obtained.

Amino- and substituted amino-groups should represent good examples of electron-releasing and, in acidic solution, electron-attracting groups. p-Aminobenzaldehyde polymerized in acidic solution, but when p-dimethyl- and p-diethylaminobenzaldehyde were treated in the usual manner, crystalline trimers were obtained, only one form being isolated (Table II).

TABLE II. Aminobenzaldehyde products.

Product	M.P.	% Yield	Anal, % S Calcd.	Found	Mol. Wt. Calcd.	Found
$(p\text{-}(CH_3)_2NC_6H_4CHS)_3$	224-5°	81	19.40	20.00	495	467
$(p\text{-}(C_2H_5)_2NC_6H_4CHS)_3$	146-8°	82	16.59	16.48	579	535
$(p\text{-}CH_3CONHC_6H_4CHS)_3$	174-6°	70	17.88	17.79		(none)
$(p\text{-}C_6H_5CONHC_6H_4CHS)_x$	264-6°	35	13.29	13.99		(none)

p-Acetaminothiobenzaldehyde was obtained also in what was apparently a trimeric form, but no cryoscopic solvent was found for it. Bromoform was found useful for the dialkylaminothiobenzaldehydes and oxygen-substituted compounds, but could not be used for the acetamino- and benzoylamino-compounds. p-Benzoylaminobenzaldehyde apparently formed a polymer, having 16 or 17 units in the chain. When the trithio-p-acetaminobenzaldehyde was hydrolyzed by boiling in aqueous HCl, some hydrogen sulfide was evolved, and a complex polymer was formed! It may be safely stated that the dimethylammonium and diethylammonium groups function as strong electron-attracting groups also, permitting only one trimer to be obtained.

Experimental

Trithio-p-acetoxybenzaldehyde: A solution of 10.1g (0.062mole) of p-acetoxybenzaldehyde in 40 ml. of glacial acetic acid containing 5ml. of propionic acid was cooled to O° in an ice bath. Hydrogen sulfide and hydrogen chloride were passed into the solution for two hours, after which the mixture was allowed to stand in the cold for one hour. The slurry of crystals was poured into cold water with stirring, and the solid filtered out and dried. The crude product was recrystallized repeatedly from methanol, yielding glittering white needles which melted at 186-7°. The yield of purified material was 2.8g. or 25%.

Anal: Calcd. for $C_{27}H_{24}O_6S_3$; %S, 17.89; m.w. 540. Found; %S, 18.06; m.w. (Cryoscopically in bromoform) 467.

When the above compound was hydrolyzed by refluxing in a mixture of ethanol and hydrochloric acid for four hours, p-hydroxybenzaldehyde was obtained in 82% yield.

Its identity was further confirmed by conversion to p, p'-diacetoxystilbene, as follows: 2.0g of trithio-p-acetoxybenzaldehyde was refluxed in 40 ml. of xylene with 2.0g of copper powder for sixteen hours, and the hot solution filtered. On cooling, a precipitate formed which yielded long white needles, after recrystallization from nitro-methane, which melted at 211-213°. ter Meer (10) reported p,p'-diacetoxystilbene to melt at 213°.

Confirmation of the *cis-trans* configuration for trithio-p-acetoxybenzaldehyde was obtained by its preparation from trithio-p-hydroxybenzaldehyde, which had previously been prepared by Kopp (11). A solution of 2.0g of trithio-p-hydroxybenzaldehyde in 15 ml. of acetic anhydride containing 5g of anhydrous potassium acetate was heated on a steam bath for two hours and poured into 50 ml. of cold water. The solid was recrystallized several times from methanol, yielding 75% of the theoretical amount of glittering white needles which melted at 187-188°, and caused no depression in melting point when mixed with the compound prepared from p-acetoxybenzaldehyde.

Trithio-4-thymolaldehyde: 4-thymolaldehyde was prepared by the method of Adams and Montgomery (12). A solution of 3.0g (0.02 mole) of this substance in 40 ml. of ethanol was cooled to —3° in an ice-salt bath, and hydrogen sulfide gas slowly bubbled in the mixture. After 10 minutes hydrogen chloride was also bubbled through the solution, and the temperature was maintained at —5° to +3°. The solution became quite viscous after two hours, and was allowed to stand in the cold for two hours longer, but no precipitate appeared. It was then poured into 200 ml. of cold water with stirring, and the white solid crystallized from hot 50% aqueous ethanol in white needles which weighed 2.8g (76%) and melted at 245-246°.

Anal: Calcd. for $C_{33}H_{42}O_3S_3$; %S, 16.48, m.w., 582. Found; %S, 16.40, m.w. (Cryoscopically in glacial acetic Acid) 483.

α-and β-Trithio-3-thenaldehydes: A solution of 5g (0.045 mole) of 3-thenaldehyde (13) in 30 ml. of a one-third saturated solution of hydrogen chloride in ethanol was cooled to —15° in a Dry Ice-ether bath, and hydrogen sulfide was bubbled into the mixture for one and one-half hours. The solution turns red, and finally forms a slurry of yellow crystals. After standing at —5° for one hour, the solid was removed, washed with cold ethanol, and dried. It weighed 5.6g (98%). It was extracted by refluxing with three 50ml. portions of boiling benzene, and the residue recrystallized from chloroform to yield small white needles of the β-isomer, melting at 217-218°, and weighing 1.4g (25%).

Anal: Calcd. for $C_{15}H_{12}S_6$; %S, 50.01, m.w. 384. Found; %S, 49.98, m.w. (Cryoscopically in napthalene) 378.

The benzene extracts of the crude thioaldehyde were evaporated to dryness on a steam bath, and the residue recrystallized twice from nitro-methane, yielding thick white needles of the α-isomer, which melted at 179-180° and weighed 1.7g (30%).

Anal: Calcd. for $C_{15}H_{12}S_6$; %S, 50.01, m.w. 384. Found; %S, 49.88, m.w. 372.

When a small sample of the α-isomer was refluxed in benzene with a crystal of iodine, it was readily converted to the higher melting β-isomer.

Trithio-p-dimethylaminobenzaldehyde: This compound was prepared in a variety of ways, in an effort to isolate a second isomer, but since the same product was obtained in all cases, only the most convenient preparation is described. A solution of 3g (0.02 mole) of p-dimethylaminobenzaldehyde in 45 ml. of 10 N hydrochloric acid was cooled to —5° in an ice-salt bath, and a vigorous stream of hydrogen sulfide was passed through the mixture for one and one-half hours. The solution was then saturated with hydrogen chloride and allowed to stand for one hour. The yellow solution was diluted with 50 ml. of cold water and then made basic with 30% potassium hydroxide solution. The crude yellow precipitate was washed with water and recrystallized from nitromethane in slender yellow needles, which weighed 2.7g (81.4%) and melted at 224-225°.

Anal: Calcd. for $C_{27}H_{33}N_3S_3$; %S, 19.40, m.w. 495. Found; %S, 20.00, m.w. (Cryoscopically in bromoform) 467.

p, p' Di (dimethylamino) stilbene: A mixture of 0.54g of trithio-p-dimethylaminobenzaldehyde and 0.56g of copper powder in 30 ml. of xylene was refluxed for seven hours. The solution exhibited a strong violet fluorescence, and after removing the coper sulfide and cooling, deposited greenish-yellow crystals which weighed 0.22g (50%) and melted at 253-254°.

Anal Calcd. for $C_{18}H_{22}N_2$; %N, 10.53. Found; %N, 10.12.

Trithio-p-diethylaminobenzaldehyde: This compound was prepared by the same procedure as given for the dimethylamine derivative. In a typical experiment, 2.0g of p-diethylaminobenzaldehyde dissolved in 40 ml. of 12 *N* hydrochloric acid gave 1.8g (82%) of the pure thioaldehyde after recrystallization from nitromethane. The yellow needles melted at 196-198°.

Anal: Calcd. for $C_{33}H_{45}N_3S_3$; %S, 16.59, m.w., 579. Found; %S, 16.48, m.w. (Cryoscopically in bromoform) 535.

Trithio-p-acetaminobenzaldehyde: A solution of 6g (0.037 mole) of p-acetaminobenzaldehyde (14) in 50 ml. of a one-fifth saturated solution of hydrogen chloride in "Cellosolve" was cooled to —25° in a Dry-Ice-ether bath, and a slow stream of hydrogen sulfide introduced for two hours. The viscous yellow mixture was let stand one hour, and then poured into 150 ml. of cold water with vigorous stirring. The oil which precipitated solidified and was crystallized from ethanol, yielding 4.5g (70%) of white crystals which melted at 174-176°.

Anal: Calcd. for $C_{27}H_{27}O_3N_3S_3$; %S, 17.88. Found; %S, 17.79.

When the above experiment was carried out in ethanol solution, a product which melted at 261-262°, and was insoluble in most organic solvents, was produced. Sulfur analysis for this compound was less than the calculated value for a trimer. Its properties suggest a linear polymer.

p-Benzoylaminobenzaldehyde oxime: Pfeiffer (15) reports the melting point of p-benzoylaminobenzaldehyde as 146-147°. When p-aminobenzaldehyde was benzoylated by the Hinsberg method in dioxane, and the product recrystallized from ethanol-water mixture, a 77% yield of a white solid which melted at 149-150° was obtained. The oxime has not previously been reported. It was prepared by the usual procedure and recrystallized from ethanol, and melted at 192-194°.

Anal: Calcd. for $C_{14}H_{12}O_2N_2$; %N, 11.66. Found; %N, 11.74.

p-Benzoylaminothiobenzaldehyde: A suspension of 24g (0.107 mole) of p-benzoylaminobenzaldehyde in 300 ml. of ethanol was cooled to 0° in an ice-salt bath, and hydrogen sulfide and hydrogen chloride passed into the mixture for three hours. The mixture was allowed to come to room temperature, and the solid collected, washed with water and dried. The 25g of crude product was dissolved in 200 ml. of boiling pyridine, and 100 ml. of chloroform added to the hot solution. On cooling, 9. Og of a white compound melting at 264-266° was obtained.

Anal: Calcd. for $C_{14}H_{11}ONS$; %S, 13.29. Found; %S, 13.99.

Assuming that the above compound is a linear polymer of the type, $HS(RCHS)_xH$, the approximate value of x may be calculated from the sulfur analysis as follows:

let p = % Sulfur by analysis
w—molecular weight of monomeric thial

$$\text{then } p = \frac{(32 + 32_x)\ 100}{34 + xw}$$

$$\text{or } x = \frac{3200 - 34p}{pw - 3200}$$

For the above analysis,

$$x = \frac{3200 - 34 \cdot 14}{241 \cdot 14 - 3200} = 17$$

Linear Polymers: When p-cyanobenzaldehyde, p-carboxybenzaldehyde, and p-carbethoxybenzaldehyde were treated with hydrogen sulfide and hydrogen chloride in cold solutions, only intractable, evil-smelling substances which were insoluble in most solvents, were obtained. Some of these were plastic in nature, and most of them contained less than the calculated amount of sulfur, indicating that the polymers formed were of the type $HS(RCHS)_x(RCHO)_yH$. All efforts to prepare crystalline trimers were fruitless.

Summary

A theory which reconciles the apparently conflicting evidence for puckered and planar configuration of the trithiane ring has been advanced. This assumes that the ring exists in only one puckered "chair" form, and unsymmetrical trithianes may form *cis-cis* and *cis-trans* isomers of this form. Evidence in support of this theory is cited.

A number of new triaryltrithianes and derivatives have been prepared and characterized, including trithio-p-acetoxybenzaldehyde, trithio-4-thymolaldehyde, α and β-trithio-3-thenaldehyde, trithio-p-dimethylaminobenzaldehyde, trithio-p-diethylaminobenzaldehyde, and trithio-p-acetaminobenzaldehyde.

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The Relative Ease of Esterification of Amino Alcohols

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Whenever in an organic compound two functional groups are present on nearby carbon atoms, each group modifies the properties of the other. For example, the *beta*-phenoxyethyl halides are relatively inert to metathetical reactions (1) which the simple ethyl halides undergo readily, and the hydroxyl groups of ethylene glycol react with hydrogen bromide much more slowly than does the hydroxyl group of methanol (2).

Although many hundred amino alcohols have been made for pharmacological testing, not much attention has been paid to the influence of the amino and hydroxyl groups on the chemical properties of each other. Glasstone and Schram (3) have shown that the hydroxyl group lowers the basicity of the amino group in a series of *beta*-amino-alcohols such as aminoethanol, 2-amino-l-propanol, etc. This is the result which would be predicted from the electron-attracting inductive effect of the hydroxyl group. Glasstone and Schram did not extend their work to amino alcohols wherein the amino and hydroxyl groups are separated by more than two carbon atoms.

Some years ago we became interested in studying the effect of the amino group on the properties of the alcoholic hydroxyl group. The reactions of alcohols are of two general types; those, such as dehydration and replacement by halogen, in which the entire OH group is lost; and those, such as esterification, in which only the hydrogen of the hydroxyl group is replaced. Tertiary alcohols, in which the electron pair of the C-O link is greatly displaced toward the oxygen atom, readily undergo the first type of reaction, while primary alcohols, in which the C-O link is relatively strong, are also stronger acids, and undergo the second type of reaction more readily. The amino group, which is relatively electron-attracting (-I effect) should tend to strengthen the C-O bond, and it would be predicted, therefore, that tertiary amino alcohols of the general type I would be more easily esterified and more difficult to dehydrate than the corresponding tertiary alcohols (II) without the amino group.

This prediction was verified, as far as dehydration is concerned, in earlier work from this Laboratory (4). Amino alcohols of type I, where R, R′ and R″ are methyl groups, are extremely resistant to dehydration until there are at least five carbon atoms (n=4) between the amino and hydroxyl groups. Whereas simple tertiary alcohols can be dehydrated by heating with iodine or copper sulfate, the amino alcohols studied in this work could not be dehydrated by such mild reagents, and it was necessary to use concentrated sulfuric acid or to pyrolyze the Grignard complex in order to obtain olefinic amines.

Other work (4, 5) on the preparation of amino alcohol esters with such reagents as benzoyl chloride indicated that the tertiary hydroxyl group is much more easily esterified than is the case with simple tertiary alcohols, but no quantitative data were reported. In the present work we investigated the esterification of a series of dialkylamino alcohols with acetic anhydride. The reactants were used in equimolar quantities, and the reactions were carried out at 100° for one-half hour. At the end of this time an aliquot portion of the reaction mixture was analyzed for acetic acid, and the remainder was hydrolyzed and the ester isolated. Duplicate runs were made in all cases; usually the results agreed within one or two percent. The results are recorded in Table I. Some alcohols not containing amino groups were esterified for comparison purposes; these results are also included in Table I.

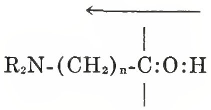
TABLE I. Esterification of Amino Alcohols with Acetic Anhydride in Benzene Solution.

100°C. 30 minutes.
0.2106 moles of each reactant

Alcohol Used	Percent of Ester Formed, Detd. By analysis	By distillation
$Me_2N\text{-}CH_2CH_2OH$	55	54
$Et_2N\text{-}CH_2CH_2OH$	83	83
$Me_2N\text{-}CH_2CH_2CH_2OH$	65	65
$Et_2N\text{-}CH_2CH_2CH_2OH$	76	—
$Me_2N\text{-}CH_2CHOH\text{-}CH_3$	81	78
$Me_2N\text{-}CH_2C(CH_3)_2OH$	69	70
$Me_2N\text{-}CH_2CH_2C(CH_3)_2OH$	86	84
$Me_2N\text{-}CH_2CH_2CH_2C(CH_3)_2OH$	53	54
CH_3CH_2OH	74	
$CH_3CH_2CH_2OH$	77	
$CH_3CHOH\text{-}CH_3$	46	
$(CH_3)_3C\text{-}OH$	11	

Certain conclusions may be drawn from the data in Table I. Secondary and tertiary alcohols containing an amino group in the molecule esterify much more completely than do alcohols of the same type without the amino group. A similar effect was not observed in the case of the primary alcohols, but this may not be significant, since primary alcohols without an amino group are easily esterified under the conditions used. In the case of tertiary alcohols the effect is still marked when the amino and hydroxyl groups are separated by four carbon atoms. The diethylamino alcohols apparently esterify more readily than do the dimethylamino analogs.

It seems to us that the effect of the dialkylamino group on the ease of esterification of an alcoholic hydroxyl group is due to two factors. The first factor undoubtedly is an electron-attracting inductive effect of the amino group operating, with diminished intensity, through the carbon chain:



$$R_2N\text{-}(CH_2)_n\text{-}\overleftarrow{\overset{|}{\underset{|}{C}}:O:H}$$

As a result of this electron-displacement toward the nitrogen atom, the oxygen atom of the hydroxyl group has less share than usual in the electron-pair binding it to the carbon atom, consequently, the hydrogen atom of the hydroxyl group is held more loosely. The concept of simple inductive effect, however, does not explain the great ease of esterification of 4-dimethylamino-2-methyl-2-butanol, since the inductive effect of an electron-attracting group operating through a saturated chain does not usually continue through more than three carbon atoms. The acid strengths of the propionic acids may be cited as an example of this: propionic acid has $K_a = 1.4 \times 10^{-5}$; alpha-chloro-propionic acid is much stronger, with $K_a = 1.47 \times 10^{-3}$ but beta-chloropropionic acid is not much stronger as an acid than the unsubstituted compound; K_a in this case is 8.6×10^{-5}.

A second factor which appears to be important in explaining the effect of the amino group on the ease of esterification of amino alcohols is chelation. If the molecule of the amino alcohol "curls up," as in all probability it does, then the amino and hydroxyl groups approach very close in space, and a hydrogen bond can be formed.

Molecular models indicate that this type of hydrogen bonding can occur readily until six carbon atoms separate the two groups. When such a chelate ring takes part in a chemical reaction the proton can remain attached to either the nitrogen or the oxygen atom. This explains the reduced basicity of the amino group and the increased ease of esterification of the hydroxyl group. The difference in effect between the dimethylamino and diethylamino groups is probably one of basic strength-diethylamine is considerably stronger as a base ($K_b = 1.26 \times 10^{-3}$) than is dimethylamine ($K_b = 7.4 \times 10^{-4}$) (6) and hence would have a greater attraction for the proton.

It might seem that the greatly increased ease of esterification of the tertiary amino alcohols could be due to simple catalysis by the tertiary amino group, since tertiary bases such as pyridine are known to catalyze some alcohol-anhydride reactions. While catalysis may play some part, we do not believe that this is a complete explanation for the results obtained in the present work, as in general the reaction of tertiary alcohols with acetic anhydride is not markedly influenced by the presence of a tertiary base. For example, Mitchell, Hawkins and Smith (7) found that at 60° tertiary butyl alcohol and acetic anhydride gave only a 6% yield of ester, even though a large quantity of pyridine was present.

Experimental

Preparation of Amino Alcohols.—These were prepared as described previously (4,8) from the chlorohydrin or, in some cases, the olefin oxide and secondary amine. The amino alcohols were purified by distillation through a Whitmore-Fenske column packed with single turn glass helices, and only those fractions of constant boiling point and constant index of refraction were used. The physical constants of the fractions employed are shown in Table II.

TABLE II. Data on Amino Alcohols.

ALCOHOL	B.pt./Press.	n_D^{20}
$Me_2N\text{-}CH_2CH_2OH$	133-134/740	1.4292
$Me_2N\text{-}CH_2CH_2CH_2OH$	159-161/740	1.4360
$Me_2N\text{-}CH_2CHOH\text{-}CH_3$	124/740	1.4192
$Me_2N\text{-}CM_2C(CH_3)_2OH$	128/740	1.4212
$Me_2NCH_2CH_2C(Me)_2OH$	79-80/50	1.4289
$Me_2NCH_2CH_2CH_2C(Me)_2OH$	96-97/27	1.4393

Esterification of Amino Alcohols.—An accurately weighed sample (0.2106 mole) of the amino alcohol in 156 g. of reagent grade anhydrous benzene was placed in a 300 ml. glass ampoule, and 0.2106 mole (20 ml.) of reagent grade acetic anhydride was added from a calibrated pipet. The ampoule was quickly sealed, shaken and immersed in a thermostat at 100°, where it was kept for thirty minutes. It was then removed, cooled in an ice bath and opened. The contents were shaken with 100 ml. of distilled water to hydrolyze unreacted acetic anhydride, and the water layer was made basic with 6 N sodium hydroxide. The organic layer was separated, dried over anhydrous potassium carbonate, filtered, and placed in a 250 ml. volumetric flask, which was then filled to the mark with dry benzene. A 10 ml. portion of this solution was removed for analysis, and the remainder was distilled through a column packed with a tantalum spiral, and the yield calculated from the weight of ester isolated. The physical constants of the aminoalkyl acetates obtained are given in Table III.

TABLE III. Data on Aminoalkyl Acetates.

Aminoalkyl Group	B.p./ Press.	n_D^{20}	d_4^{20}	MR_D Calc.	obs.	M.p. of HCl Salt
$Me_2N\text{-}CH_2CH_2\text{-}$	150/740	1.4161	0.9290	35.6	36.2	130-131
$Et_2N\text{-}CH_2CH_2\text{-}$	112/80	1.4238	0.9124	44.7	44.5	113-114
$Me_2N\text{-}CH_2CH_2CH_2\text{-}$	114/120	1.4207	0.9178	40.1	40.1	118-119
$Me_2N\text{-}CH_2CH(CH_3)\text{-}$	151/740	1.4133	0.9058	40.0	40.1	125-126
$Me_2N\text{-}CH_2C(CH_3)_2\text{-}$	159/740	1.4179	0.8955	44.7	44.8	143
$Me_2N\text{-}CH_2CH_2C(CH_3)_2\text{-}$	120/100	1.4257	0.8995	49.4	49.3	180-181
$Me_2N\text{-}CH_2CH_2CH_2C(CH_3)_2\text{-}$	119/50	1.4287	0.8902	54.0	54.2	133-134

Analytical Method.—The usual procedure for determining acetyl groups had to be modified because of the presence of the amino group, and the following technique was devised. The 10 ml. aliquot of the benzene solution was refluxed for one hour with methyl alcoholic sodium prepared by dissolving 0.5 g. of clean sodium in 14 ml. of reagent methanol, and adding 2 ml. of boiled distilled water. The solution was then distilled to dryness under reduced pressure in a small Kjeldahl apparatus. The residue was taken up in 10 ml. of distilled water and 5 g. of reagent sodium dihydrogen phosphate and 10 ml. of reagent 90% phosphoric acid were added. The mixture was distilled almost to dryness at 60 mm. pressure from an oil bath kept at 100°; the distillate was collected in a known volume of standarized barium hydroxide solution. Three 10 ml. portions of distilled water were added to the residue, the mixture being evaporated almost to dryness each time. The excess barium hydroxide was titrated to the phenolphthalein end point with 0.1 $\underline{N}$ hydrochloric acid. The whole operation, except the titration, was carried out in the same apparatus, which was protected from carbon dioxide by means of potassium hydroxide towers. Control experiments showed that the amount of acetic acid liberated could be determined with an accuracy of 1%.

Summary

1. The ease of esterification of certain amino alcohols by acetic anhydride has been determined under constant conditions. It has been shown that secondary and tertiary alcohols containing an amino group esterify much more readily than do the analogs without an amino group.

2. An explanation has been developed for these observations.

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The Relative Stability of Some Nickel (II) Complexes[2]

E. St. Clair Gantz and Ethyl Shannon Forlaw[1], Purdue University

Coordination compounds have received considerable attention because of the belief that an understanding of the forces which hold these combinations together may lead to a better understanding of the general nature of these forces. One indication of the strength of these bonds is to be found in the stability of the complexes. Very little study has been made of the stabilities of the nickel (II) complexes.

In view of this, a spectrophotometric study was made of the relative stabilities of some of the nickel (II) complexes using a Beckman model (DU) spectrophotometer to measure the transmittancy of the various anions in the range 225 mμ to 400 mμ at intervals of 10 mμ. Since each complex has certain characteristic features in its transmittancy, it was possible to compare curves of individual anions with those of mixtures of anions and establish relative stabilities of the complexes.

The only values found in the literature for instability constants were for the cyanide, bromide, and citrate complexes. Sartori (1) gives 3.45×10^{-16} for tetracyanonickelate (II); Bobtelsky and Jordan (2) give 4.1×10^{-4} for a citrate complex; and Job (3) gives 6.03×10^{-4} and 1.32×10^{-5} for $NiBr_2$ and $(NiBr)^-$ respectively in the presence of some HBr, but full details are not given in the article.

H. C. Jones (4) in a series of publications reported studies of absorption spectra of over 2000 different solutions. Very little data are given as to the relative or actual stabilities of the complexes.

Experimental

In order to compare the stability of the complex nickel anions, use was made of reactions of the type:

$$2\ K^+ + (NiX_4)^{-2} + 4\ (K^+ + Y^-) \rightleftarrows 2\ K^+ + (NiY_4)^{-2} + 4\ (K^+ + X^-).$$

The original complex was made in solution by adding the proper amount of potassium salt to the simple nickel compound, (NiX_2 + 2 KX). The solutions were 0.10 M nickel and 0.40 M anion. To the mixture, for comparison purposes, was added an equivalent amount of a second potassium salt (KY) for the possible formation of a complex of nickel with Y. Equilibrium was approached from both directions, i.e. starting with K_2NiX_4 and adding KY; starting with K_2NiY_4 and adding KX. The foregoing statement is true except for measurements using tartrate and thiocyanate, in these cases the potassium salt was added in all cases to the other nickel salts.

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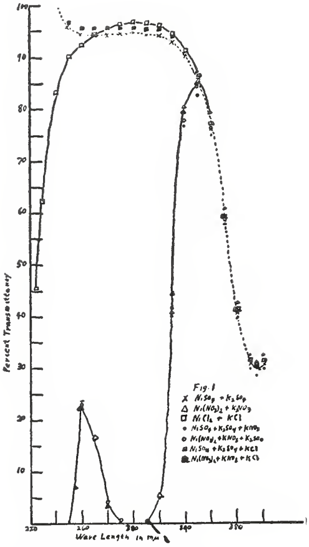
[2] Abstracted from the thesis presented to the faculty of Purdue University in partial fulfillment of the requirements for the M. S. degree, Feb. 1948.

Transmittancy measurements were made with a Beckman model (DU) spectrophotometer. The light source was a hydrogen discharge lamp. Silica cells were used; the one used for the water blank had a cross-section of 1.008 cm, the one for the solutions 1.003 cm. The temperature range was 23°C. to 30.5°C.

All salts were A.C.S. reagent grade except the potassium tetracyanonickelate (II) which was furnished by Dr. W. C. Fernelius. All water used was redistilled.

In figures 1, 2, 3, and 4, it is shown how the relative stability was established. In each figure the ordinate is the percent transmittancy and the abscissa is the wavelength in millimicrons.

The relative stability was established by comparing the transmittancy curve of a mixture of two anions being studied with the transmittancy curve of each anion. The curve of the anion that the mixture more nearly resembled was the curve of the more stable complex.



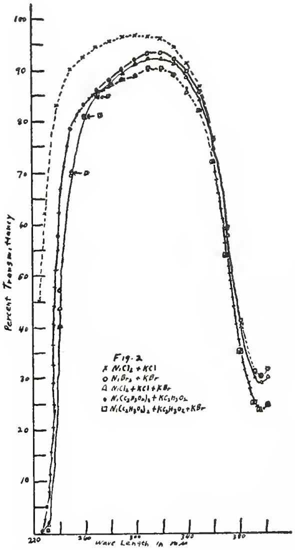
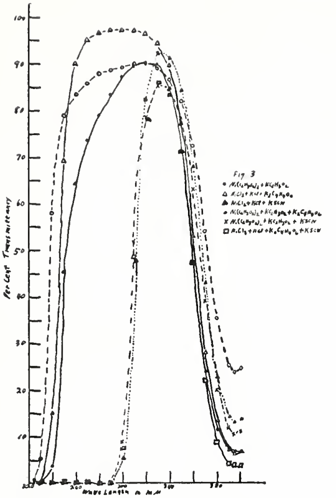


Fig. 1. Transmittancy curves for Nickel (II) complexes of X) Sulfate; Δ) Nitrate; □) Chloride; ●) Sulfate and Nitrate; ○) Nitrate and Sulfate; ■) Sulfate and Chloride; ▲) Nitrate and Chloride.

Fig. 2. Transmittancy curves for Nickel (II) complexes of X) Chloride; ○) Bromide; Δ) Chloride and Bromide; ●) Acetate; □) Acetate and Bromide.

Figure 1 shows that the sulfate, nitrate, and chloride have about the same degree of stability. The part of the curve from 250 mμ to 340 mμ in the case of all solutions containing nitrate is due to the nitrate ion itself.

Figure 2 shows that the bromide complex is more stable than the chloride complex and that the acetate complex is still more stable.



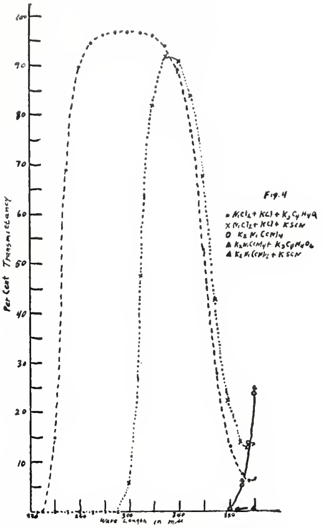


Fig. 3. Transmittancy curves for Nickel (II) complexes of ○) Acetate; Δ) Tartrate; ▲) Thiocyanate; ●) Acetate and Tartrate; X) Acetate and Thiocyanate; □) Tartrate and Thiocyanate.

Fig. 4. Transmittancy curves for Nickel (II) complexes of •) Tartrate; X) Thiocyanate; ○) Cyanide; ▲) Cyanide and Tartrate; ▲) Cyanide and Thiocyanate.

Figure 3 shows that the tartrate and thiocyanate complexes are both more stable than the acetate complex. The curve for the mixture of tartrate and thiocyanate is about half like one and half like the other so it was concluded that these two complexes had about the same degree of stability.

Figure 4 shows that the cyanide complex is the most stable of the complexes studied.

Results

The relative stability observed for the nickel (II) complexes, the most stable being listed first, is as follows:

Cyanide
Tartrate, Thiocyanate
Acetate
Bromide
Sulfate, Nitrate, Chloride.

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The Preparation of Some Dialkylaminoalkyl Esters of Phenoxyacetic Acids*

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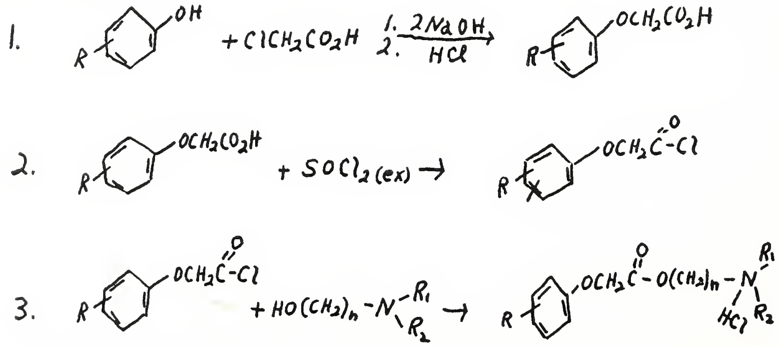
Ever since the elucidation of the structure of cocaine by Willstäter et al (1) in 1898, attempts have been made to synthesize better local anesthetics without the undesirable physiological properties of the natural product. One of the first of the synthetic local anesthetics, which was not closely related to cocaine in structure, was prepared by Einhorn and Uhlfelder (2) in 1909. This compound was the diethylamino-ethyl ester of p-aminobenzoic acid and was called "novocaine" or more recently "procaine."

Since the synthesis of "procaine," there have been literally thousands of compounds prepared and tested for local anesthetic activity; but, as yet, no one has managed to prepare a more versatile anesthetic. The results which have been obtained in this search are conflicting and vary over wide limits, and no general correlation of structure with physiological activity has been made in this field. This lack of correlation is most striking when one considers the lack of specificity in the acids which have been esterified with amino alcohols.

A search of the literature failed to reveal the preparation of dialkylaminoalkyl esters of any phenoxyacetic acids. The high activity of certain substituted phenoxyacetic acids as plant hormones (3) suggested the possibility of other physiological action. Therefore, a series of basic esters was prepared for test as local anesthetics. Meanwhile, Truitt et al (4) and Martin and Hafliger (5) reported the preparation of a large number of basic esters of various substituted phenoxyacetic acids for testing as antihistaminic agents. However, neither group reported any work on the esters of p-nitrophenoxyacetic acids and p-aminophenoxyacetic acids with which this work is concerned.

The procedure used for the preparation of the esters is illustrated by the equations:



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* Abstracted from a thesis to be submitted by Raymond Boucher to the faculty of Indiana University in partial fulfillment of the requirements for the degree Master of Arts in the Department of Chemistry.

$R = H, NO_2-, 2,6\text{-}diCH_3$
$N = 2, 3$
R_1 and $R_2 = CH_3, C_2H_5, N\text{-}C_3H_7, N\text{-}C_4H_9, \beta$ - morpholino
$R_1 = \Phi, R_2 = C_2H_5$

The method of Jacobs and Heidelberger (6) was used to prepare both the p-nitrophenoxyacetic acid and the p-nitrophenoxyacetyl chloride. The esterification reaction was run in dry benzene from which the product usually separated as a heavy oil which crystallized on cooling. Absolute ether was added to the cold benzene solution to precipitate the remainder of the salt. All the hydrochlorides but one (the morpholino derivative) were very hygroscopic so that the isolation and recrystallization were difficult. In general the compounds were recrystallized from absolute alcohol-absolute ethyl acetate mixtures or from the latter solvent.

Attempts to isolate the products obtained after reduction using Adam's Catalyst (on the free bases) and Palladium on charcoal (on the hydrochlorides) presented many difficulties and at best only small yields of impure product were obtained. The p-aminophenoxyacetic acid esters obtained were oxidized even on very brief exposure to air, causing the reduced alcohol solutions to become intensely colored. Since these compounds were being prepared to be tested as local anesthetics, this extreme instability was very disadvantageous. Attempts to distill the free bases under reduced pressure resulted in decomposition and only tars were obtained as a residue. The hydrochlorides were precipitated with absolute ether and were highly colored viscous oils or glasslike amorphous solids which would not crystallize.

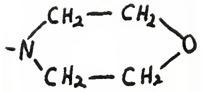
The decomposition of p-aminoethers in the presence of mild oxidizing agents was studied quite thoroughly in the case of p-anisidine (7) as early as 1910. Wieland assumed that the decomposition occurred with the formation of an intermediate quinoid structure. Aniline, methanol and anisole were isolated from the reaction mixtures even after the reactions had been run only a few minutes. It is then reasonable to assume that similar decomposition probably occurs with the p-aminophenoxy acetates. No attempts were made to isolate any of the probable breakdown products in this decomposition reaction.

$$p - X\,\Phi - OCH_2CO_2(CH_2)_n - NR_1R_2$$

Experimental

Diethylaminoethyl phenoxyacetate hydrochloride: A solution of 8g (0.046 mole) of phenoxyacetyl chloride in 65 ml of dry benzene was placed in a three-necked flask equipped with a reflux condenser, a mechanical stirrer and a dropping funnel. A solution of 8g (0.068 mole) of β-diethylaminoethanol in 30 ml of dry benzene was added drop-wise to the vigorously stirred cold acid chloride solution at such a rate that no hydrogen chloride fumes were perceptible. A light yellow oil, which crystallized to a white amorphous solid, separated from the reaction

Table I. Properties of Esters.

X	n	R_1	R_2	Yield %	*M.P. °C	Chlorine%	
						Calcd.	Found
H	2	C_2H_5-	C_2H_5-	79	112-3.5	12.04	11.79
NO_2	2	CH_3-	CH_3-	71	164-5	11.63	11.40
NO_2	2	C_2H_5-	C_2H_5	83	107-8	10.66	10.45
NO_2	2	n-C_4H_9-	n-C_4H_9-	52	88-90	9.12	9.23
NO_2	2	C_2H_5-	C_6H_5	41	133-4	9.13	9.18
NO_2	2			63	192-3	10.22	10.19
NO_2	3	n-C_3H_7-	n-C_3H_7	72	88-9	9.43	9.28
NO_2	3	n-C_4H_9-	n-C_4H_9	72	108-9	8.80	8.51
NO_2	3	n-C_4H_9-	n-C_4H_9-	20-5	144-7	9.51	9.52

* Uncorrected.

mixture. The ester hydrochloride was recrystallized twice from an absolute alcohol-absolute ether mixture. (Properties in Table I.)

Dialkylaminoalkyl esters of p-nitrophenoxyacetic acid:

Diethylaminoethyl p-nitrophenoxyacetate hydrochloride: This compound was prepared using the same procedure as was used for the diethylaminoethyl phenoxyacetate hydrochloride except that in this case the reaction mixture was allowed to reflux for about 30 minutes after complete addition to the aminoalcohol. A solution of 22g (0.19 mole) of diethylaminoethanol in 100 ml of dry benzene was added to a solution of 40g (0.19 mole) of p-nitrophenoxyacetyl chloride (6) in 150 ml of dry benzene. A viscous light brown oil, which solidified on cooling, separated from the reaction mixture. About 200 ml of absolute ether was added to the benzene solution to insure complete precipitation. The ester hydrochloride was recrystallized twice from 5% absolute methanol in absolute ethylacetate. (An alternative recrystallization procedure was to dissolve the ester hydrochloride in absolute alcohol and add absolute ether until a cloudiness develops.) (Properties in Table I.)

The same general procedure was used in the preparation of all the p-nitrophenoxyacetate hydrochlorides.

Dialkylaminoalkyl p-aminophenoxyacetates: Distilled water solutions of 20g (0.05-0.065 mole) of the p-nitrophenoxyacetate hydrochlorides were treated with dilute sodium carbonate solution until the solution was basic. The heavy oils which separated from the basic solution were extracted with three 50-75 ml portions of ether and the ether extracts combined and placed over anhydrous sodium sulfate. The dried extracts were filtered and the ether removed under reduced pressure leaving close to the theoretical amount (95-100%) of viscous light yellow oils. The free bases were taken up in 125 ml of absolute alcohol and 0.2g of platinum oxide catalyst added. The reductions were done using low pressure hydrogenation apparatus (initial pressure about 40-45 lbs.) and the reduction began immediately. The reaction mixture warmed considerably as the reduction proceeded and the theoretical amount of hydrogen was used up in about 15-30 minutes, depending on the ester being reduced. The catalyst was removed by filtration or centrifugation and the alcohol solutions concentrated under reduced pressure yielding highly colored concentrates which were taken up in ether. Dry hydrogen chloride gas was passed into the ether solutions to precipitate the amine hydrochlorides.

Reduction of the p-nitrophenoxyacetate hydrochlorides was done in the same manner using Palladium on charcoal as a catalyst. Absolute ether was added directly to the filtered absolute alcohol solution to precipitate the amine hydrochlorides.

Summary

The following esters have been prepared from the appropriate acid chloride and aminoalcohol: β-diethylaminoethyl phenoxyacetate hydrochloride, β-dimethylaminoethyl p-nitrophenoxyacetate hydrochloride, β-diethylaminoethyl p-nitrophenoxyacetate hydrochloride, β-di-n-butylaminoethyl p- nitrophenoxyacetate hydrochloride, β-ethyl-β-phenylaminoethyl p-nitrophenoxyacetate hydrochloride, β-morpholinoaminoethyl p-nitrophenoxyacetate hydrochloride, γ-di-n-propylaminopropyl p-nitrophenoxyacetate hydrochloride, γ-di-n-butylamino-propyl p-nitrophenoxyacetate hydrochloride, and γ-di-n-butylaminopropyl p-aminophenoxyacetate hydrochloride.

The difficulties encountered in the attempted catalytic reduction of the p-nitrophenoxyacetates are discussed.

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The Distribution of Carbon Between the Zirconium and Ferrite Phases[1]

W. P. FISHEL, JOHN C. HAYES[2], Vanderbilt University

A previous investigation by Rhoad (1), on the distribution of carbon between the zirconium and ferrite phases, confirmed the existence of zirconium carbide (ZrC) as a crystalline constituent, which could be identified microscopically, and which could be separated by the solution method. It also indicated that in some iron-carbon-zirconium alloys, part of the zirconium occurred in some form which was soluble in dilute acids. This work is concerned mainly with the carbide forming tendency of zirconium, and the effect of zirconium on the carbon content of the eutectoid mixture.

Zirconium in iron-carbon alloys is capable of reacting with carbon to form zirconium carbide (ZrC), and with iron to form iron zirconide (Fe_3Zr_2). Its distribution between these two phases must depend upon the affinities of zirconium for iron and carbon, and the relative atomic ratios of these elements present in the steel. Indications are that both are practically insoluble in solid iron. Hence, they could not contribute to precipitation hardening, and should be considered as inclusions.

In order to be a part of the Ar_1 transformation, zirconium carbide must separate from the austenitic solid solution at the Ar_1 temperature. If zirconium does take part in this transformation, the percent of carbon in the eutectoid mixture will be increased or decreased, depending upon the effect of zirconium on the Acm and A_3 transformations.

Zirconium occurring as a solid solution with ferrite should be found in the solution of the reagent used to dissolve the steel sample. If zirconium is an avid carbide former, it would be expected that in steels whose atomic ratios of carbon to zirconium are less than one, all of the carbon would form zirconium carbide, and the remaining zirconium would form a solid solution with ferrite. If the atomic ratio of carbon to zirconium is greater than one, all the zirconium would form zirconium carbide. However, if zirconium is not a strong carbide former, then the presence of other elements would influence the distribution of carbon to a greater extent. Some relation similar to the mass law would apply.

The iron-carbon system of Vogel and Loehberg (2) which is approximated from their data shows that the carbon content of the iron-carbon (carbide) eutectoid increases progressively with zirconium. Shapiro and Strauss (3) have interpreted this diagram to mean that the carbon content in the eutectoid mixture is increased with increasing zirconium. This may be true, but it does not take into account the fact that zirconium forms a carbide. If zirconium forms a carbide, the amount of carbon necessary for this formation is removed from solution, and more carbon is then necessary for the formation and separation of the eutectoid mixture. If zirconium does increase the carbon content in the eutectoid mixture, then zirconium must take part in the eutectoid separation and must be a part of it.

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[1] This paper contains material from the thesis of John C. Hayes, presented to the faculty of Vanderbilt University, in partial fulfillment of the requirements of the M. S. degree, June, 1944.

[2] Present address: Chemistry Dept., Purdue University.

Experimental Procedure

Several zirconium steels were prepared by melting pure materials in an induction furnace, fitted with a silica tube for vacuum melting. An evacuated system was used due to the ease with which zirconium unites with oxygen and nitrogen. The alloying agents used were Armco iron, graphite, zirconium carbide, and ferro-silicon-zirconium. The Acheson graphite crucibles were lined with a mixture of four parts sintered and ground magnesium oxide to one part unsintered magnesium oxide, moistened with a saturated solution of magnesium chloride. The lined crucibles were baked at 120°C. for several hours and then baked in the induction furnace for 10-15 minutes before the charge was added. The ingots were turned down on a lathe to sound metal, and then turnings were collected for chemical analyses. A section was cut from the sound metal of each alloy for microscopic analysis.

Analytical Procedure

The method used to separate zirconium occurring in the carbide phase from that occurring in some other phase was by digesting the ingot turnings in hydrochloric acid (sp. gr. 1.1) and then determining the amount of zirconium dissolved and that undissolved. The zirconium found in the residue was considered to be zirconium carbide, and that soluble in the acid to be zirconium occurring in some other phase. Zirconium was determined by precipitation with phenylarsonic acid, according to Rhoad (1).

> Carbon was determined by the standard combustion method, using 2.0 gm. samples.
>
> No determination was made for the silicon present in any alloy.
>
> A summary of the analysis of the alloys of this study is given in Table I.

Discussion

By plotting the atomic ratios of zirconium to carbon against the percent of the total carbon existing as zirconium carbide, figure I is obtained. The carbon united with zirconium was calculated from the zirconium found in the residue. This diagram shows that all the carbon exists as zirconium carbide if the atomic ratio of zirconium to carbon

TABLE I

ALLOY	% C.	% Zr	% Zr / % C	% of Total / Zr. in Res	At. % Zr. / At% C	C as ZrC / % of Total
2	0.14	0.13	0.93	100.00	0.12	12.24
3	0.16	0.071	0.44	100.00	0.06	5.85
5	1.11	0.254	0.23	25.66	0.03	3.02
6	0.56	0.086	0.15	86.03	0.02	2.02
7	2.92	0.923	0.32	78.76	0.04	4.17
11	0.168	1.62	9.65	100.00	1.32	100.0
12	0.16	1.58	9.75	87.00	1.28	100.0
Rhoad's Samples						
9	0.75	1.315	1.75	61.75	0.23	23.12
13	0.86	0.958	1.11	94.5	0.15	14.69
14	0.56	1.246	2.22	56.8	0.29	29.3
15	0.86	0.306	0.36	44.0	0.05	4.8
18	1.52	1.993	1.31	79.8	0.17	17.2

is greater than one. Data for atomic ratios of zirconium to carbon between .3 and 1.28 is lacking. The points for atomic ratios below .3 form almost a straight line, which seems to indicate that a distribution law must apply in this case.

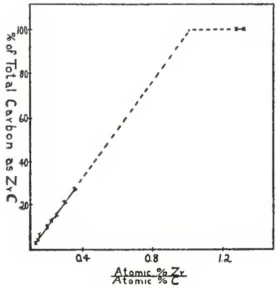

Figure I

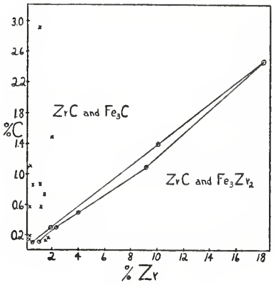

Figure II

The data obtained from the alloys of this study and from those of Rhoad (1) agree with the inferences of figure II, which is approximated from the data of Vogel and Loehberg (2). All alloys above the curve show zirconium carbide, and iron carbide, as pearlite or as pearlite and cementite. In this area the ratio of zirconium to carbon is less than one. The two points below the curve are alloys No. 11 and No. 12, which showed zirconium carbide, and a lacy network which is probably iron zirconide, but no iron carbide was present. In this area, the ratio of zirconium to carbon is greater than one.

The preparation of a group of zirconium steels, whose atomic ratios of zirconium to carbon varied widely, was difficult. Zirconium carbide and ferro-silicon-zirconium were the only available sources of zirconium. The quantity of zirconium carbide was very limited, and when alloys were prepared with this compound, the percent of zirconium to carbon could not be varied. The ferro-silicon-zirconium contained about one-third zirconium and about one-half silicon, so that a large amount of silicon was necessarily present.

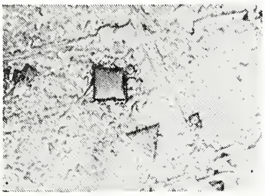
Figure III

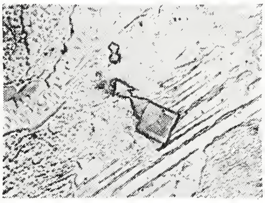

Figure IV

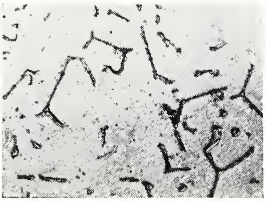
Figure V

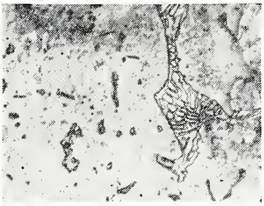
Figure VI

Fig. 3. Alloy #7, unetched. X750. Zirconium Carbide Crystals. Zr. =0.923% (0.732% insol.) C=2.92%.

Fig. 4. Alloy #7. Etchant: sodium picrate. X750 Zirconium carbide crystals and cleavage planes cementite.

Fig. 5. Alloy #12. Etchant: nital. X750 abundance of crowfoot structure.

Fig. 6. Alloy #11. Etchant: nital. X750. Lacy network and absence of pearlite.

Zirconium and the Eutectoid Mixture

In order to show that zirconium does not take part in the eutectoid transformation, three of the samples (Nos. 5, 7, and 12) which showed an abundance of zirconium carbide crystals and crowfoot structure, were held at 400°C. for two hours, then quenched in ice water. If zirconium takes part in the Ar_1 transformation, it must go into solution on heating and reprecipitate at the Ar_1 temperature. A section from each of the quenched samples was polished and examined. This examination revealed the presence of the crowfoot structure, characteristic of ZrC. The form and the amount of ZrC had not been changed by the heating and the quenching. Since the ZrC structure is still present at 900°C., its formation must occur at a higher temperature. According to

Vogel and Loehberg, the temperature of this formation is about 1330°C. for alloys rich in Zr, and about 1145°C. for those poor in Zr. (figure 7.)

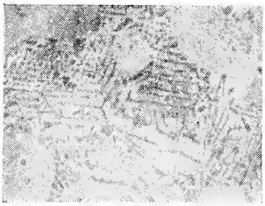

Fig. 7. Alloy #5. Unetched. X700. 900° for two hours, water quenched.

Conclusions

1. All the carbon in a steel whose atomic ratio Zr:C is greater than 1, will be united with the Zirconium.

2. If the ratio Zr:C is less than 1, there is a fairly direct ratio between this and % of Total carbon as ZrC.

3. Fe_3C appears only if Zr:C is less than one.

4. Zirconium does not enter Ar_1 transformation because ZrC separates in the crystalline or crowfoot structure at a temperature well above the Ar_1; *therefore zirconium* does not increase the carbon content of the eutectoid, as stated by Strauss.

However in order to have a matrix of pearlite, the steel must contain more than 0.85% C. The excess carbon unites with zirconium, and is in no way connected with the eutectoid separation.

5. ZrC particles in steels function as inclusions *only*.

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The Chemistry of Controlled Mutations

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Mutations may be produced in plants and animals in three ways. In a few cases a reasonably accurate prediction of mutation that will occur under carefully controlled conditions can be made. We have recently become much more interested in the study of the causes of cancer. We know that a tendency to acquire cancer may be inherited. Studies of cancer in animals have shown that some strains of laboratory animals are much more susceptible to cancer than are other strains. Since cancer itself is not inherited it is not considered to be a mutation. Natural mutations do occur, but hybridization and selection somewhat increase their frequency of occurrence. This method of producing mutations has given mankind many of the plants and animals that now exist. The Concord grape and the Starking apple are good examples of mutations produced by this method. The seedless orange and the seedless grape are also mutations of more or less accidental origin. There is safety in numbers. Only by producing a large number of plants is there very much chance of a mutation occurring. Mutations are not always improvements. They may be of less value than the parent type in many instances. Those types of little worth are seldom propagated while the more valuable types are very commonly grown.

The second method of producing mutations is by the use of radiations. The X-ray is probably the most valuable of all radiations in producing new varieties of plants. Radioactive elements and compounds may give us many kinds of mutations in plants and animals. Their present use is largely confined to studies in growth and nutrition. The chemical changes occurring in plant and animal life can be traced by means of radioactivity.

The third way of producing mutations is by chemical treatment. When a chemical compound or mixture partially dissolves a cell wall and acts within the cell it is very effective in the production of mutations. It is well known that it is difficult to determine whether some kinds of living cells are plant or animal. There are many instances of chemically induced mutations in plants but it is more difficult to determine how mutations may be produced in animal life. From the similarity in cell structure it would seem that any chemical that proved to be particularly effective in making cellular changes in plants might be expected to perform a similar function in changing the cell structure in animals. The first mutation that commonly occurs when certain forms of animal life are given proper doses of certain chemical mixtures is the increased rate of reaction to stimuli. The response may be more easily produced with a comparatively weak stimulus with a decrease in reaction time. Bees and other insects show an ability to assimilate the chemicals quite rapidly and show a decrease in reaction time by moving the wings more rapidly and producing a tone of higher pitch than the controls that were not given the chemicals. Pigeons show a more rapid response to a stimulus applied to either of their feet. Their increased ability to quickly find their way through a maze shows that there may be a corresponding increase in intelligence when they are fed these chemicals. There seems to be some increase in flying ability. As it has been impossible for accurate measurements to be made because of the lack of adequate equipment these observations cannot be regarded as scientific evidence but are merely my own opinion on this matter. Cuprammonium hydroxide, ethyl nitrate, and partially nitrated cellulose may be used to make up a chemical mixture for this purpose. It is probable that glutamic acid could be given immediately after the cuprammonium hydroxide solution to obtain similar results. These chemicals must be given in very small amounts which can be determined only by experimentation.

Hyperglycemia may be expected to be a symptom of a slight overdose of a mixture of these chemicals. An amount must be given that is sufficient to produce a physiological reaction. The chemicals tend to have an accumulative action when several doses are given. As cases of fusion occur in plants in quite a few instances it seems reasonable to assume that a similar fusion of axones of neurones may be the cause of a lessened reaction time in animals. There are two theories of impulse conduction; the contact theory and the continuity theory (1). It has been shown that an axone could be excited by placing it very near another axone of the same type which received an electrical stimulus (2). It has been suggested that life originated by chemical combinations of nonliving matter (3, 4). This opinion does not imply that life was not created.

The chemical treatment of plants is not difficult, but no result may occur if the solution is too dilute. Serious burning of the foliage and other undesirable results are apt to occur when too strong a solution is used. A strong solution usually produces an undesirable mutation. To make a solution, ammonium hydroxide is mixed with copper sulfate until all the mixture is of a purple color, then a mixture of napthalene and carbon disulfide is added to it. One ounce of cuprammonium hydroxide shaken well with an ounce of a saturated solution of napthalene in carbon disulfide should be put in from five to ten gallons of water for best results. The solution should then be sprayed on the plants to be treated. The concentrated mixture shows the Brownian movement very well under the microscope. It is probable that this bombardment effect changes the arrangement of the genes in the chromosomes. Polyploid forms are common. The somatic chromosome number can be changed by such treatment. The accompanying photographs show some of the results obtained.

With dogwood the change was from a simple leaf to a compound leaf. In potato, variegated leaves were obtained. Peanuts produced four peanuts per pod instead of the usual number.

Pansies produced ruffled flowers instead of the normal type. Tomatoes were produced with part of the carpels seedless when the plants were treated lightly. Plants given excessive treatment produced small, seedy fruit and the stems of the plants were greatly thickened. Carrots produced additional divisions of the leaf at the midrib of the leaf. In gourd, two types of gourd were produced from the same vine. Parts of the vine assumed various polyploid forms as shown by a fusion of parts in the stems and flowers. In crab apple double flowers were produced by pruning and chemical treatment, but the effect was not repeated the following year when the flowers were normal. With asparagus a height of nine feet was reached while the stems were sometimes flattened and the number of branches were sometimes doubled. Phlox produced several kinds of dwarf plants of the perennial phlox, while the phlox, Drummondi, produced stems several feet in length and bloomed freely. Jerusalem artichoke produced seed and grew to a height of from eight to ten feet. Russian sunflower was dwarfted to several feet in height and produced no seed when excessive treatment was given. Catnip produced stems of about twice normal width. Fuller's tease produced dwarf growth. Tulips produced branched stems. *Aristolochia serpentaria* showed an increase in height.

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Certain Condensations of Polyamines and Polyfunctional Compounds*

John W. Schick with Ed. F. Degering, Purdue University

The purpose of this investigation was to study the reactions of diamines and other polyamines with such polyfunctional compounds as 2,2′-dichloroethyl ether, 1,4-dibromo-2-butene, chloroacetyl chloride and silicon tetrachloride. The results from such condensations have yielded fiber producing compounds, rubber-like products, and resins.

Experimental

Hexamethylenediamine and 2,2′-dichloroethyl ether:

Eighty-seven grams of hexamethylenediamine (0.75 mole), dissolved in 100 ml. of 50% ethyl alcohol, was placed in a three-necked flask equipped with a dropping funnel, condenser, and a mechanical stirrer. One hundred and eight grams of 2,2′-dichloroethyl ether (0.75 mole) in 100 ml. of ethyl alcohol was added dropwise with continued stirring and gentle heating. After the complete addition (2½ hours), vigorous stirring and refluxing were continued for 7 hours. The reaction product, when cooled, could be pulled into fibers. The alcoholic solution was evaporated and the product became solid (m.p. 159°C.). When the solid was heated on a steam cone, it softened sufficiently so that it could be drawn into fibers. The fibers, however, were somewhat brittle and soluble in water.

When pyridine and ethyl alcohol were used as solvents for the condensation, a viscous, orange-brown product was obtained which could be drawn into fibers 10 feet long before breaking.

Hexamethylenediamine and 1,4-dibromo-2-butene:

Fifty-four grams of 1,4-dibromo-2-butene in 100 g. of dibutyl ether was added dropwise over a period of several hours to a refluxing solution of 38 g. of hexamethylenediamine in 100 g. of dibutyl ether with vigorous stirring. A gummy precipitate began to form and it increased as the 1,4-dibromo-2-butene solution was added. When the addition was almost completed, the solution became difficult to stir. The product was filtered and dried. The product had no sharp melting point but decomposed on heating. It was insoluble in water, benzene, chloroform, and pyridine and only slightly soluble in hydrochloric acid. A sample of the product, when placed in a hydraulic press at 5000 lbs./sq. in. and 150°C., yielded a disc which was slightly pliable. It lacked the strength of the common thermosetting plastics.

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* This is an abstract of a portion of a thesis submitted to the faculty of Purdue University in partial fulfillment of the requirements for the Doctor of Philosophy degree by John W. Schick.

Hexamethylenediamine and chloroacetyl chloride:

Twenty-nine grams of chloroacetyl chloride (0.25 mole) in 100 g. of dibutyl ether was added dropwise over a period of several hours to 29 g. of hexamethylenediamine (0.25 mole) in 100 g. of dibutyl ether under reflux. As the addition was continued, a precipitate began to cling to the sides of the flask and stirring became difficult. When the product began to darken, further heating was discontinued. The solution was cooled and the solid product was filtered. The product was suspended in 100 ml. of a 10% caustic solution and vigorously stirred. The suspended product was filtered and as much of the aqueous solution as possible was pressed out and the residue was washed with acetone and air dried. The product had the appearance of sponge rubber. It had a slight resiliency and a certain toughness to stretching. It was insoluble in water, pyridine, carbon disulfide, petroleum ether, glacial acetic acid, ethanolamine, tetraethylenepentamine, 2-nitropropane-butanol mixture, acetone, alcohol and ether. It was soluble in formamide. Suspension of the product in acetone and then extrusion resulted in a fiber with slight resiliency.

1,3-Diaminobutane and silicon tetrachloride:

One gram of silicon tetrachloride was added dropwise to one gram of 1,3-diaminobutane with vigorous stirring. The reaction was violent. The solution turned orange in color and became very viscous. When the product was cooled, it became a clear glassy resin. The product could be drawn into fibers when warmed to the softening point. The fibers, however, were brittle and very hygroscopic.

Tetraethylenepentamine and silicon tetrachloride:

Two grams of silicon tetrachloride was added dropwise to two grams of tetraethylenepentamine with vigorous stirring. The solution became viscous and formed a putty-like material. The putty could be bounced, but it did not show any flattened surfaces from the violent contacts.

A Rapid Method for the Estimation of Alcohols

HOWARD BURKETT, DePauw University

In connection with another research problem it became necessary to estimate the quantity of methanol present. Since many samples were to be analysed, it was desirable that the method be as rapid as possible. Methods reported in the literature for the determination of alcohols are all based upon the reaction of the alcohol with acetic anhydride or acetyl chloride, followed by hydrolysis of the excess reagent, according to the following equations:

$$ROH + CH_3COCl \rightarrow CH_3COOR + HCl$$
$$CH_3COCl + H_2O \rightarrow CH_3COOH + HCl$$

The difference in titre between a blank and a determination is a direct measure of the amount of an alcohol present.

Reported methods (1) were for various reasons considered to be unsatisfactory. Some of them were required two to twenty-four hours for each determination. Some required a large volume of solvent. One (2) required only twenty minutes for the reaction with the acetyl chloride, without solvent, to be completed, but this one required dry ice, which was not readily available to the author.

The method finally employed made use of pure acetyl chloride and simple, readily-available equipment. The reaction was carried out in a 20-ml. bottle and the reagents were introduced through a tight-fitting stopper. Stoppers of various materials were tried. All, including neoprene, rubber and tygon, absorbed acetyl chloride to a certain extent. Rubber seemed to be the least objectionable in this respect, but satisfactory results depended upon the use of as small a stopper as possible and the control of the time of contact with the stopper. With suitable care check results of within ±0.3% were obtained.

Acknowledgment.—The author thanks Commercial Solvents Corporation for the support which made this work possible.

Experimental

Numerous preliminary experiments are, of course, omitted.

Equipment.—A 1-ml. tuberculin syringe, a 10-ml. syringe, two ⅝-inch, 25-gauge hypodermic needles, two 20-ml. bottles[1] with ¼-inch openings at the neck and a supply of ¼-inch rubber stopples[2].

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[1] The bottles used in this work had contained Eli Lilly and Company Physiological Salt Solution.

[2] Furnished by Commercial Solvents Corporation.

Procedure.—Two determinations were performed simultaneously. Each bottle was handled as follows: About 0.3 ml. of acetyl chloride was placed in the bottle and the stopple inserted. The bottle was shaken and let stand for five minutes[3]. The stopple was removed and the bottle half-filled with water. The bottle was shaken with the stopple in place; then the contents emptied. The bottle was filled with water, one-half poured out; then shaken with the stopple in place and emptied. It was then rinsed three times with small amounts of acetone and dried with a current of air. The stopples were placed in a small beaker and rinsed three times with acetone and air-dried for about five minutes. The stopple was inserted and fastened tightly. Using the tuberculin syringe, exactly 0.300 ml. of acetyl chloride was introduced through the stopple. In order to avoid parallax a piece of paper was glued onto the syringe opposite the 0.300 graduation. The bottle was shaken and let stand for five minutes. By means of the 10-ml. syringe, about 10 ml. of water was injected into the bottle and the bottle was shaken with the needle in place. About 11 ml. of air was withdrawn from the bottle into the syringe, which was then removed from the bottle. The stopple was removed and the contents of the bottle were poured into an Erlenmeyer flask. The bottle was filled with water, one-half emptied into the Erlenmeyer, the bottle shaken with the stopple in place and the remaining water poured into the Erlenmeyer. The contents of the Erlenmeyer were titrated with standardized alkali, using phenolphthalien indicator. This is the blank titration.

The bottles and stopples were rinsed and dried as described above and used for an actual determination, the only difference in procedure being that a weighed sample, sealed in a small, thin-walled glass bulb, was placed in the bottle before the stopple was inserted and that the glass bulb was broken by shaking after the addition of the acetyl chloride. If a series of determinations is interrupted for more than a few minutes, it is necessary to pretreat the rubber stopples again with acetyl chloride before continuing. Each day a new blank should be run.

Results.—Table I shows a series of consecutive determinations, except that the pure methanol was run along with a different series at a different time.

Summary

A procedure is described for the determination of methanol, using acetyl chloride as the reagent. The reagent which does not enter into ester-formation is hydrolyzed and titrated with standardized alkali. A 20-ml. bottle is used as the reaction vessel and the reagent is introduced quantitatively, by means of a syringe, through a rubber stopple in the bottle.

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[3] If the stopples were not subject to about the normal exposure to acetyl chloride before starting, the first determination would give a low value.

TABLE I.

Material	Sample Weight	Titre N=.2618	Blank less Titre	Percent Methanol
	Blank	32.96		
	Blank	33.04		
	Av.	33.00		
4	.1345	31.80	1.20	8.0
4	.1525	31.69	1.31	7.6
7	.1391	29.72	3.28	21.0
7	.1779	28.82	4.18	20.9
8	.1266	27.50	5.50	38.6
8	.1259	27.58	5.42	38.2
9	.1103	25.74	7.26	58.6
9	.1327	24.47	8.53	57.1
	Blank	32.92		
	Blank	32.96		
	Av.	32.94		
Methanol	.0986	21.88	11.07	99.8

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1. A list of references appears in an article by Petersen, J. W. Hedberg, K. W. and Christensen, B. E., Ind. Eng. Chem. Anal. Ed., **15**, 225 (1943), and in the following reference.

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Oxidations with Selenium Dioxide

D. J. Cook, R. W. Sears, and Darrel Dock, DePauw University

Selenium dioxide has been used as a selective oxidizing agent for activated methyl groups in many different types of compounds (1). Most frequently the oxidation reaction is performed in some inert solvent such as ethyl alcohol or xylene. It has been found that nitrogen heterocyclic compounds of the type 1,4-dimethylcarbostyril and 5-keto-7-methyljuloline were best oxidized to the aldehyde when selenium dioxide was added to the fused substance over a temperature range of 145-175°.

The oxidation of 1,4-dimethylcarbostyril to the 1-methyl-4-carbostyrilcarboxaldehyde has already been reported (2). It has been found that the yield of this preparation can be increased from 70% to 95-98% by increasing the size of the reaction mixture from 0.11 mole of the 1,4-dimethylcarbostyril to 0.22 mole or more of the carbostyril. The increased batch size apparently gives better mixing and the oxidation can be carried almost to completion.

The oxidation of three other compounds, 1-ethyl-4-methyl-carbostyril, 1-benzyl-4-methylcarbostyril and 5-keto-7-methyljuloline by an analogous method gave 1-ethyl-4-formylcarbostyril, 1-benzyl-4-formylcarbostyril and 7-formyl-5-ketojuloline.

Experimental

1,4-Dimethylcarbostyril, 1-ethyl-4-methylcarbostyril and 1-benzyl-4-methylcarbostyril were prepared by a method described by Kaslow and Cook (3). Reissert has reported the preparation of 5-keto-7-methyljuloline by the action of ethyl acetoacetate on tetrahydroquinoline (4). We have improved this preparation by the use of diketene with tetrahydroquinoline. The selenium dioxide was prepared by the action of nitric acid on selenium and purified by immediate sublimation.

1-Methyl-4-carbostyrilcarboxaldehyde.—In a 500 ml., three-necked, round-bottomed flask equipped with an air condenser and mechanical stirrer was placed 38.0 g. (0.22 mole) of 1,4-dimethylcarbostyril. The flask was heated in an oil-bath to 150°. To the fused material 28 g. (0.252 mole) of selenium dioxide was added gradually over a period of thirty minutes. During this time stirring was continuous and the temperature was allowed to rise to 175°. The fused mass was maintained at this temperature with stirring for forty-five minutes or until the mass solidified. When cool, the mixture was ground to a powder and extracted twice with 400 ml. of boiling benzene and thee times with 200 ml. of boiling benzene. The combined extracts were filtered, evaporated to about 600 ml. and cooled in the refrigerator. Yellow needles of 1-methyl-

4-carbostyrilcarboxaldehyde were obtained which melted at 179-180°. Evaporation of the filtrate to about 300 ml. gave a small additional yield. The total weight of product was 40.7 g. (98%). An alternate method of extraction can be used by means of a large Soxhlet extractor with about 600 ml. of benzene used as the solvent.

1-Ethyl-4-formylcarbostyril.—In a manner analogous to the preparation of 1-methyl-4-carbostyrilcarboxaldehyde, 19g. (0.10 mole) of 1-ethyl-4-methylcarbostyril was treated with 13.9 g. (0.125 mole) of selenium dioxide. The reaction mass solidified on cooling and was then extracted with two portions of 200 ml. of boiling benzene and four portions of 100 ml. of boiling benzene. The combined extracts were evaporated to 400 ml. and orange-brown needles of the aldehyde crystallized. The weight was 19.8 g. (97%). The product after recrystallization from benzene melted at 117.5-119°.

Anal. Calcd. for $C_{12}H_{13}NO_2$:	N, 6.96
Found:	N, 7.41

The 2,4-dinitrophenylhydrazone was prepared and found to melt at approx. 315-320° (dec.).

1-Benzyl-4-formylcarbostyril.—In a like manner 20.0 g. (0.083 mole) of 1-benzyl-4-methylcarbostyril was oxidized with 10.5 g. (0.094 mole) of selenium dioxide. The reaction mass when extracted with boiling benzene, evaporated and allowed to cool gave yellow needles weighing 11.5 g. (56%). The m.p. of the crude product was 159-160°. A 2 g. sample was recrystallized from 20 ml. of benzene. The m.p. was 161.5-162.5°.

Anal. Calcd. for $C_{17}H_{13}NO_2$:	N, 5.32
Found:	N, 5.03

The 2,4-dinitrophenylhydrazone was prepared and found to melt at 253-255° (dec.).

5-Keto-7-methyljuloline.—In a 250 ml., three-necked flask equipped with a mechanical stirrer, reflux condenser and dropping funnel was placed 20 g. (0.150 mole) of 1,2,3,4-tetrahydroquinoline and 50 ml. of benzene. The solution was heated to reflux on a steam-bath and 12.8 g. (0.188 mole) of diketene was added dropwise. The mixture was then allowed to reflux for four hours. At the end of this time the benzene was drawn off under reduced pressure. The red oil which remained was added in 2 ml. portions to 20 ml. of concentrated sulfuric acid at such a rate that the temperature was held between 100-110°. This mixture was heated on a steam-bath for 10-15 minutes. The sulfuric acid solution was then poured into 150 ml. of ice water and neutralized with 15-16 g. of solid sodium hydroxide. A tan colored, solid, product precipitated which, when dried, weighed 21.2 g. (73%). This material, when recrystallized from benzene-petroleum ether, melted at 130.5-131.5°. Reissert reported a melting point of 129.8°.(4)

Anal. Calcd. for $C_{13}H_{13}NO_2$:	N, 7.03
Found:	N, 6.79

7-Formyl-5-ketojuloline.—In a manner which has been described for the preparation of 1-methyl-4-carbostyrilcarboxaldehyde, 9 g. (0.045 mole) of 5-keto-7-methyljuloline was oxidized with 5.2 g. (0.047 mole) of selenium dioxide. The residual mass was extracted three times with 200 ml. of boiling benzene, filtered and the combined extracts evaporated to about 200 ml. Ten to fifteen milliliters of petroleum ether was added to the benzene solution and, upon cooling, yellow crystals formed. The product weighed 8.2 g. (84%) and when recrystallized from benzene gave a melting point of 149-150°.

Anal. Calcd. for $C_{13}H_{11}NO_2$:	N, 6.57
Found:	N, 6.28

Summary

Additional studies of the oxidation of 1,4-dimethylcarbostyril with selenium dioxide have given an increase in the yield of 1-methyl-4-carbostyrilcarboxaldehyde from 70% to 98%.

Several new aldehydes, 1-ethyl-4-formylcarbostyril, 1-benzyl-4-formylcarbostyril and 7-formyl-5-ketojuloline have been prepared.

The preparation of 5-keto-7-methyljuloline has been improved over that of the method of Reissert by the use of diketene with tetrahydroquinoline.

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Some p-Nitro- and p-Aminobenzoates of Sulfur-containing Alcohols[1]

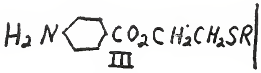
E. CAMPAIGNE and PHILIP R. FERGUSON, Indiana University

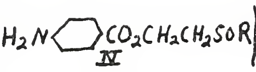
The effect of replacing oxygen by sulfur atoms in physiologically active compounds has been frequently studied, as in alkamine esters of furoic and thenoic acids (1), the alkamine esters of p-aminothiolbenzoic acid (2, 3) and the alkamine esters of p-methylmercaptobenzoic acid (4). However, no examples have been reported in which the effect of replacing the nitrogen atom by sulfur has been determined. Since sulfur lies between oxygen and nitrogen in its ability to form onium salts, it may be able to replace nitrogen in certain physiologically active compounds. For instance, acetylcholine (I) exerts powerful physiological effects,

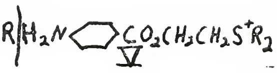
$$\underset{\text{I}}{CH_3COOCH_2CH_2N^+(CH_3)_3} \qquad \underset{\text{II}}{CH_3COOCH_2CH_2S^+(CH_3)_2}$$

but the activity of the β-acetoxyethyl dimethylsulfonium compound (II) has not been determined.

To test this hypothesis, an attempt was made to prepare the p-aminobenzoates of some alkylmercaptoethanols (III), alkylsulfonylethanols (IV) and dialkylsulfoniumethanol salts (V).







These were to be tested as local anesthetics, comparing their activity to procaine. However, only the sulfonyl esters (IV) were prepared in the pure form, the other two types being highly unstable and difficult to purify. The sulfonyl esters were apparently completely devoid of local anesthetic activity. Impure β-ethylmercaptoethyl p-aminobenzoate and β-n-butylmercaptoethyl p-aminobenzoate were qualitatively active by tongue test, but have not been obtained in pure form for quantitative testing.

The sulfonyl esters were prepared by esterifying the β-alkylmercaptoethanols with p-nitrobenzoyl chloride, oxidizing the ester to the sulfone, and catalytically reducing the nitro group. This procedure gave pure products in high yield. The intermediate alkylmercaptoethyl p-nitrobenzoates could not be purified, as they were oils which decomposed on distillation at reduced pressure. The p-nitrosulfones derived from these esters were crystalline and analyzed correctly, showing that the sulfide ester had been obtained.

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[1] Abstracted from a thesis submitted by Philip R. Ferguson to the faculty of Indiana University in partial fulfillment of the requirements for the degree Master of Arts in the Department of Chemistry, October, 1948.

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Two methods were tried in an attempt to prepare pure β-alkylmercaptoethyl p-aminobenzoates. Reduction of the impure p-nitrosulfides was unsuccessful. Chemical reduction with tin or iron in hydrochloric acid led to complexes which were intractable. Low-pressure catalytic reduction using palladium chloride on charcoal resulted in hydrogenolysis of the sulfide linkage, so that ethyl p-aminobenzoate and the alkylmercaptan were obtained. The mercaptans were not isolated, but were evident by their odor and by strong nitroprusside tests. Coupling potassium alkylmercaptides with β-chloroethyl p-aminobenzoate in alcohol solution produced crude oils or low-melting solids which were extremely unstable, and only amorphous products which contained less than the calculated amount of sulfur were obtained.

Treatment of these impure p-aminosulfides with alkyl halides formed crude salts which were also unstable and were not further investigated. It would be of interest to determine whether the sulfide or the amine group coupled preferentially in this reaction.

Experimental

β-Ethylsulfonylethyl p-Nitrobenzoate:

A solution of 40.6 g. (0.38 mole) of β-ethylmercaptoethanol, prepared by the method of Fromm and Jorg (5), and an equimolar amount of p-nitrobenzoyl chloride (75 g.) in ether was shaken, and 35 g. of pyridine was added dropwise. The pyridine hydrochloride which precipitated was removed by filtration, and the ether removed under reduced pressure. The resulting yellow, viscous oil weighed 83 g., equivalent to 85% yield of pure product. A solution of 15 g. (0.06 mole) of the crude p-nitrosulfide was dissolved in 100 ml. of glacial acetic acid, and 40 ml. of 30% hydrogen peroxide added. After standing for 48 hours at room temperature, the solution was diluted with cold water, and the crystals which separated were filtered and dried. After recrystallization from ethanol, 16.6 g. (98%) of glistening white plates which melted at 110-111° were obtained.

Anal: Calcd. for $C_{11}H_{13}O_6NS$; %S, 11.17. Found, %S, 11.33

β-Ethylsulfonylethyl p-Aminobenzoate:

A 10 g. sample (0.035 mole) of β-ethylsulfonylethyl p-nitrobenzoate was dissolved in 150 ml. of ethanol and 0.2 g. of Adams platinum oxide catalyst (6) added to the solution in a pressure bottle. The bottle was placed in a low-pressure hydrogenation apparatus and shaken until a pressure drop of 9 lbs. of hydrogen had occurred. The catalyst was removed by filtration, and the ethanol solution distilled. The amine was obtained by dilution with water, and recrystallized from ethanol-water mixture. It was obtained as white crystals, soluble in acid and melting at 115-116°.

Anal: Calcd. for $C_{11}H_{15}O_4NS$; %S, 12.45. Found; %S, 12.69.

β-n-Butyl sulfonylethyl p-Nitrobenzoate:

Since the reaction of ethylene oxide and butyl mercaptan gave greatly reduced yields of β-n-butylmercaptoethanol, crude β-n-butylmercaptoethyl p-nitrobenzoate was prepared in a different way. A solution of potassium butylmercaptide was prepared by dissolving 4 g. (0.44 mole) of butylmercaptan in 20 ml. of ethanol containing 2.5 g. (0.044 mole) of potassium hydroxide. To this was added a solution of 10 g. (0.044 mole) of β-chloroethyl p-nitrobenzoate (7) in 30 ml. of ethanol. After standing at room temperature for 24 hours, the solution was diluted with water and extracted with ether. After drying, the ether was removed and 8.4 g. (67%) of a yellow oil was obtained. This crude sulfide was oxidized in theoretical yield to the sulfone, which was obtained in white plates, melting at 63-64°.

Anal: Calcd. for $C_{13}H_{17}O_6NS$; %S, 10.16. Found; %S, 9.90.

β-n-Butylsulfonylethyl p-Aminobenzoate:

Catalytic reduction of the purified β-n-butylsulfonylethyl p-nitrobenzoate proceeded smoothly and quantitatively, yielding β-n-butylsulfonylethyl p-aminobenzoate in white crystals which melted at 93-93.5° after purification.

Anal: Calcd. for $C_{13}H_{19}O_4NS$; %S, 11.23. Found; %S, 11.61.

Summary

The p-nitro- and p-aminobenzoates of β-ethylsulfonylethanol and β-n-butylsulfonylethanol have been prepared and characterized. These esters are apparently devoid of local anesthetic action.

Efforts to obtain the corresponding esters of β-ethylmercaptoethanol and β-n-butylmercaptoethanol were not successful.

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ENTOMOLOGY

Chairman: W. P. ALLYN, Indiana University

Edward Kintner, Manchester College, was elected chairman for 1949.

ABSTRACTS

Anax longpipes Hagen (Odonata; Aeshnidae), an Atlantic Coastal Species in Indiana. B. ELWOOD MONTGOMERY, Purdue University.—*Anax longpipes* is apparently common in the Atlantic coastal area from Massachusetts to Brazil, although relatively few specimens are ever captured. There are several records of this species in the region west of the Appalachian Mountains, chiefly from Ohio. However, all but one of these records are based upon sight identification of the insect in flight. The species was added to the Indiana list from such a record in Clark County. In early July, 1948, a specimen was taken at Scales Lake State Forest in Warrick County.

The Describers of Odonata. B. ELWOOD MONTGOMERY, Purdue University.—The authors of the names, proposed for species, sub-species and categories of lower rank in the Odonata have been compiled from the Williamson-Montgomery index to the literature of the Odonata.

Linnaeus described 22 species of Odonata in the 10th edition of the Systema Naturae in 1758. Since that time about 183 authors have described or otherwise proposed names for species and groups of lower rank in the Odonata. Of these, about 60 have named but one species, about 15 two species and about 20 three or four species. The "Father of Odonatology," Edmund de Selys-Longchamps, is the author of 1121 names, more than one-fifth of those in the index. Four of these authors were native to the state or did much of their work in Indiana.

Insecticidal Control of the Clover Root Borer

Hylastinus obscurus (Marsh.)[1]

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Agriculture, Agricultural Research Administration,
Bureau of Entomology & Plant Quarantine.

One of the most serious insect pests of red clover in Ohio and Indiana is a small beetle called the clover root borer, *Hylastinus obscurus* (Marsh.), belonging to the family Scolytidae. The principal characteristic of clover infested by this insect is the failure of the second-year plants to recover after the first hay crop is removed in June. Second growth is weak, and blossoms are sparse and scattered. When infestations are heavy, many plants make no second growth and die.

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[1] Bur. Ent. and P. Q. MS. 9168.

[2] Resigned June 30, 1948; now Associate in Entomology, Purdue University Agricultural Experiment Station.

The adult stage is reached in late July and August. Migration to new clover may occur in the fall and is usually completed in April and Early May of the following year. The females burrow into the crown of the clover plant and lay their eggs in the galleries late in April and in May. Upon hatching the larvae burrow and feed in the roots. Pupation occurs in these burrows in July.

Since this insect is inside the clover roots during the entire period of development, control is difficult. Plowing severely infested fields in July or after second harvest in August to destroy the larvae and pupae does not permit the growing of a seed crop. Chemical control of the insect in the roots is difficult, as tunnel openings are small and chemicals sufficiently toxic to destroy the insects are liable to be injurious to the clover plant also. Experiments are underway to test various organic insecticides mixed with the soil before the clover is planted, but no data of significant value have yet been obtained. The possible use of any of these insecticides for soil treatments, particularly benzene hexachloride, may be limited by their effect on plant growth or flavor of crops grown in the treated soil, as determined by further investigations.

During 1947 some preliminary experiments were conducted at Croton, Ohio, to prevent infestation of newly seeded red clover by the use of organic insecticides having residual toxicity. Three insecticides—DDT, chlordane, and benzene hexachloride—were applied to the plants and soil surface with a 36-inch hand fertilizer applicator. DDT and chlordane were applied as 1% dusts at the rate of 5 pounds of active ingredient per acre, and benzene hexachloride as a 0.25% gamma dust at 1.25 pounds of the gamma isomer per acre. Examinations by dissection of 15 to 17 roots per plot from each of the four replications gave the results from the May 7, 1948 application as follows: 3.6 borers per root in the untreated plots, 2.5 borers per root in the plots treated with DDT, 0.2 borers per root in the plots treated with chlordane, and no borers per root in the plots treated with benzene hexachloride.

Oriental Fruit Moth Control by Spraying

C. Edw. Marshall, Purdue Agricultural Exp. Station

The Oriental fruit moth entered Indiana in the late 20's, and spread rapidly into all the peach growing sections of the State. As early as 1930 infestations had begun to be so heavy that the growing of this crop became hazardous in many sections. Within the next few years it was suggested by the experiment station itself that varieties of peaches grown and ripening later than midseason Elberta be dispensed with to prevent crop losses, and to eliminate varieties which would permit the development of late broods of the moth permitting it to successfully overwinter. Following this, such late varieties as Fleener, White Heath, and Williams Favorite and so-called "pickling peaches" passed out of the picture. Between 1932 and 1936 it was not uncommon for such late varieties, where they had not been destroyed, to be 95 per cent infested by the Oriental fruit moth by ripening time.

Not only were the late varieties heavily infested, but in many instances midseason Elberta carried from 35 to 65 percent infestation in the fruit at harvest time. This led to the harvesting and sale of fruit that was hard ripe, and of rather poor quality in order that the fruit could be picked and sold before the full fourth brood of the Oriental fruit moth had a chance to attack.

In Indiana, three methods of control of the insect were attempted, each with a measure of success, but only one of them outstanding. These were by parasite introduction, mechanical control, and by spraying. Immediately after the pest became well established in Indiana, and as a result of research work done in New Jersey and other eastern states before the arrival of the insect in this state, it was possible to attempt control by the introduction of parasites and predators. This work was cooperative with the United States Department of Agriculture. Approximately half a dozen species of parasitic hymenopterus insects were introduced. Of the several species of hymenoptera colonized only one *Macracentrus ancylivorus*, gave promise of being of economic importance. Scores of liberations were made, and these scattered over the entire state. Liberations made during the summer of one year were followed by the recovery collections and rearings the next year. In this way it was found that in the sandy and low lying or level sections this parasite became established very readily, and it soon brought the Oriental fruit moth attack on peaches down to 20 percent or less. This did not take place, however, in the knob or ridge orchard localities having heavy clay soils. Repeated attempts to recover the parasites, after colonization a year earlier, failed. This then is where the work of introducing parasites finally stood. The reason why *Macracentrus ancylivorus* was unable to establish itself in orchards with heavy soils was never learned.

A few years after the parasite work began, an effort was made to control the Oriental fruit moth mechanically. The larvae of the first three broods of this species attack and feed on the succulent, rapidly growing twigs of the peaches. It requires fifteen to eighteen days, according to the temperature, for them to become full fed. It was surmised control could be obtained by clipping off the wilted or infested twigs. First an attempt was made to clip off all the infested twigs about twice during the larval life of fifteen to eighteen days. This was found to be insufficient so, in later studies, the clipping was done every five days. If such intervals are maintained in the clipping, it was found that on an average one larvae was destroyed to every two twigs clipped. The work was finally carried to the 90 odd acre Wood-Gamble orchard at Sullivan to learn whether or not it was practicable on a commercial scale. It was found to offer a great deal of promise in control though the high old trees in this orchard made the labor cost high, and the height of the trees made it difficult to see newly wilted twigs.

For this reason an orchard of Gage Elberta peaches was grown low (no tree more than nine feet high) in order that the infested twigs would be more accessible. To further reduce the cost of the work below that expended when ladders were used, stilts were substituted. By growing the trees low, and by using stilts instead of ladders the labor cost of the operation was reduced a third. Not only were the infested twigs removed, but with the numerous times the trees were inspected it was not difficult to remove practically all defective fruits.

As the program was finally perfected, the Oriental fruit moth could easily be held to less than 15 percent infestation if the clippings was continued through the third brood. In addition the curculio was brought to a standstill inasmuch as the defective peaches were removed whenever they were noticed during the clipping operation. Most important, brown rot, which follows with proportional severity the attacks of curculio and Oriental fruit moth, ceased to be a threat. All in all then the clipping operation proved to be a good and practical operation in peach plantings grown to facilitate the practice. Its adoption, however, was limited to sections where Macracentrus ancylivorus could not be successfully colonized.

During the intervening period between the introduction of the Oriental fruit moth in Indiana, and the advent of DDT every spray material or combination of dust and spray that seemed to offer promise in control was given a trial on plot tests. The nearest approach to success was through the use of a five percent oil-sulphur dust developed in Illinois. Though the claim for the material was that it would, if used four or five times beginning a month before harvest and at five day intervals, control up to 50 percent of the Oriental fruit moth larvae, this was not enough. In south central Indiana the attack too often reached 60 percent, and with 50 percent control the loss of peaches to the insect was still 30 percent which is too high.

After the advent of DDT, control seemed rather simple as the result of our having worked out the clipping program so completely. We knew that the larvae spend fifteen to eighteen days in the twigs, that in that time they go from one twig to another and in all each larvae attacks an average of five twigs. We also knew that it is the fourth brood that enters the Gage Elberta variety with which we were working. Since the succulent peach twigs grow very rapidly it is difficult to keep them covered with spray material. It was early decided that to prevent attack the trees would need to be sprayed often with the insecticide. Applications of eight ounces of actual DDT were put on every five days beginning just before the first hatch of the fourth brood of larvae. This done the program went well from the standpoint of control and application. The control of the insect was very satisfactory (2.5 percent wormy as compared to an infestation of 23.7 percent in the neighboring orchard).

Such a program when presented to growers and entomologists led to considerable discussion for it was believed that as a result of four or five applications of DDT so late in the season the residue of DDT would be above the tolerance set by the Food and Drug Administration. No analysis of DDT in the harvested fruit had been made between the last application and harvest so there could be no certainty as to this point. However, in order to reduce the possibility of such being the case, the 1948 plot spray treatments were worked out keeping this in mind.

Instead of directing the DDT spray program against the fourth brood of larvae of the Oriental fruit moth it was applied to control of the third brood. This left almost a month between the last DDT spray and harvest. Such a program worked more successfully than any used earlier, and the harvest infestation was .025 percent Oriental fruit moth this year. In the first place it controls the Oriental fruit moth after late July thereby giving the twigs on the trees a chance to get considerably more growth before fall without being attacked by the Oriental fruit moth as was usually the case. This past season especially was growth needed for the second brood had attacked practically every succulent twig. In addition, from observations made to date, two and possibly only one, DDT spray in addition to those for Oriental fruit moth control may be necessary for the control of the peach borer, *Sanninoidea exitiosa* (Say). The program aids indirectly in brown rot control, and it is very effective against the second generation attack of the plum curculio. If no DDT has been applied earlier in the season it is probable that a serious spider mite problem will not develop for in the two years of the study there has been no serious mite population built up. The program fits well with the use of benzene hexachloride for the control of curculio, and with the use of chlordane for the control of insects causing cat-facing or for curculio.

One disadvantage which will be voiced against this kind of control is that it is a spray instead of a dust program. However, it may be that further study will lead to a satisfactory dust program. Meanwhile, and for the first time since the introduction of the Oriental fruit moth into Indiana, the latest ripening varieties of peaches that can be grown in this state may be planted with certainty that this pest, for a time uncontrollable, can be held in almost complete check. Now again we are growing "pickling peaches" such as Salberta, Fleener, White Heath, and Autumn, the latter a new variety developed in New York and one ripening just before freezing weather.

The Introduction of Exotic Species of European Corn Borer Parasites in Indiana

M. Curtis Wilson

Purdue University Agricultural Experiment Station

It has long been known that the natural enemies of our major pests play a significant role in control. In an attempt to increase natural control, workers of the Bureau of Entomology and Plant Quarantine studied the biological control of the corn borer in its natural habitat in Europe. Before introducing a species to a new environment it is necessary to ascertain all the facts of its biology. Misjudgment in this matter can be catastrophic. It must be certain before introducing a new species that there will be no way in which it could possibly get out of hand in its new environment. The habits of the insect must be known as well as the climatic and environmental factors which influence its development. Above all the species to be introduced must be specific in its host selection. Yet, it is desirable for the parasite to have a secondary host which is a related species to the primary host so that it may survive through seasons when the primary host population is low.

After determining those natural enemies which were specific to the corn borer in Europe the more promising species were brought to America and colonized at the federal parasite laboratory in Moorestown, New Jersey. From there they have been distributed to Indiana and other corn borer infested states.

During the past five years the Purdue University Agricultural Experiment Station has received the following species of corn borer parasites for liberation in Indiana: *Lydella grisescens*, *Macrocentrus gifuensis*, *Horogenes punctorius*, and *Chelonus annulipes*.

Lydella grisescens R. and D. is a Tachinid fly. Oviposited near borer tunnels, the egg hatches immediately and the young maggot searches out the host larva. It succeeds best against the older instar borers but due to the long preoviposition period, it is necessary to release the adult parasites when the host larvae are very small.

Probably the most easily established of our exotic corn borer parasites this Tachinid fly seems to increase very rapidly and has been known to parasitize the borer to the extent of 50 percent or higher within two or three seasons. It was first introduced in Indiana in Tipton County where it destroyed 30 percent of the corn borers last season. It was found that it had also established itself in a number of other counties and promises to become a factor in the control of the corn borer.

Macrocentrus gifuensis is a polyembryonic species. It deposits its eggs directly within the host larva attacking the younger stages of the borer. From five to forty parasites may be obtained from a single host.

More difficult to establish than *Lydella grisescens* this braconid increases and disperses more slowly during the first few years following establishment. However, in some localities, particularly in Southern New England, it has finally surpassed all other parasites combined. *Macrocentrus* has been extensively released in Indiana but has never been recovered. Colonies released this year were concentrated in the northern counties, LaPorte and Steuben. It is believed that these counties have a cooler season more comparable to that of New England than counties further south. It is hoped that they may gain a foothold there and then gradually work south throughout the state.

Horogenes punctorius, an ichneumonid, attacks the mid-instar borers. It has become established in some localities where other parasites have failed. It was released in Marshall and Jasper counties in Indiana but has not been recovered. When once established it is known to be quite persistent and remarkably stable after reaching equilibrium.

Chelonus annulipes Wesm. is a braconid which first attacks the corn borer in the egg stage. The parasite oviposits in the corn borer egg, but does not kill the borer until it is nearly full grown. It has never become abundant in the United States. In Indiana it was released in Tipton County and has been recovered once. It is believed that it may be effective in some very restricted localities. It is abundant in Europe in only one region, the Po River Valley in Italy.

Parasites have been released in 31 counties as follows: Adams, Benton, Blackford, Boone, Clay, Carroll, Cass, Clinton, Fayette, Fountain, Fulton, Grant, Hamilton, Hendricks, Henry, Jasper, Kosciusko, LaPorte, Marshall, Marion, Miami, Newton, Putnam, Porter, St. Joseph, Switzerland, Tipton, Tippecanoe, Vermillion, Warren, and White.

TABLE I. *Lydella grisescens* Recovery in Indiana in 1947.

County	No. of Collections	No. of Borers Observed	Number Parasitized	Percent Parasitized
Benton	5	57	4	7.0
Blackford	3	30	3	10.0
Clay	2	3	2	66.7
Hamilton	5	38	11	28.9
Henry	5	73	3	4.1
Jasper	19	377	48	12.7
St. Joseph	5	59	4	6.8
Tipton	25	560	168	30.0

When introduced into a new environment, parasites encounter obstacles such as differences in climate, abundance of host, etc., to which they must adapt themselves if they are to survive. To determine the degree of success met by these parasites in establishing themselves a survey was made during the fall of 1947 and another is being planned this fall. Corn borer larvae were collected in the various counties where parasites had been liberated. These were shipped to the Moorestown laboratory where they were processed by placing them in rearing cages to determine the parasites which emerged. Collections were of necessity small in some counties due to the low population of corn borers. *Lydella grisescens* was the only species recovered. The following table shows the number and percent of borers parasitized.

Although the number of parasites recovered was quite low in most of these counties the data are indicative that *Lydella* has become established and should eventually increase and spread over Indiana.

A Simple Larvacide for Ornamental Pools and Spawning Ponds

W. P. Allyn, Terre Haute, Indiana

An effort has been made to prepare an effective larvacide for ornamental pools and spawning ponds with a minimum of time, equipment, and materials. It has been noted that mosquito larvae, especially the anopheles, inhabit such bodies of water and thrive even in the presence of fish. The Anopheles larvae confine their activities in the main to the surface of the water, and often take refuge among lily pads and other water plants, and escape the feeding range of minnows and other small fish.

Materials and Equipment

The materials used, with the exception of concentrated oil-pyrethrum extract, can be obtained at the corner grocery: kerosene, any good graulated laundry soap, chemical water softener or common bath salts (trisodium phosphate), concentrated oil-pyrethrum extract (pyrethrins 2.0 grams per 100 cc.)*, and water.

No special equipment is needed. A two-gallon granite kettle, a graduate, and a five-gallon kerosene can are adequate.

Preparation of Stock Solution

One hundred grams of granulated soap and 20 grams of water softener (tri-sodium phosphate) are added to three quarts of water and boiled vigorously in the granite kettle until all ingredients are in solution. The solution is then transferred to the five-gallon can.

Immediately while the soap solution is hot, one gallon of kerosene, to which 800 cc. of oil-pyrethrum extract has been added, is poured gradually into the hot water soap solution and the mixture shaken vigorously for five or ten minutes. A very satisfactory emulsion can be obtained within a very few minutes. The stock solution, if kept in a light-proof container and in a reasonably cool place, retains its strength for months.

Application of the Larvacide

One part of the stock solution of larvacide is added to seven parts of warm soft water and applied to the surface of the ornamental pool with an ordinary two-gallon knapsack sprayer.

Mosquito larvae have been observed to succumb readily in the presence of the larvacide, yet no damage to fish or plant life has been noted. The general health and vigor of water cress, lilies, and other water plants seems to improve with the use of the larvacide, perhaps because of the control of other parasitic insect pests.

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* Pyrocide-20, produced by McLaughlin Gormley King Company, Minneapolis, Minnesota, has been found very satisfactory.

GEOLOGY AND GEOGRAPHY

Chairman: Floy Hurlbut, Ball State Teachers College

Preston McGrain, Indiana Flood Control and Water Commission, was elected chairman for 1949.

ABSTRACTS

On the Outstanding Features of the Great Climatic Cycle, A. V. Lott, Sellersburg.—Studies of cyclic variations in world climates have revealed the existence of a variation which covers such a long period that it may aptly be called "the great climatic cycle." The last cycle of this series began in Paleozoic time and continued into the recent epoch of earth history.

Variations during the period have ranged from the highly developed system of zonal climates which prevails today to the mild and relatively uniform climates of the middle to late Mesozoic. At the beginning of the cycle in Paleozoic time conditions seem to have been similar to the conditions of today. This was followed by a period of widespread continental glaciation, then by a period of mountain building, then by cool temperate climates which developed into warm temperate and then into climatic uniformity. This was followed by warm temperate which developed into cool temperate conditions, then into mountain building, then into a period of widespread continental glaciation and finally into the climates of today.

The author suggests a possible cause of such variations and explains how each climatic condition may develop.

Trends in the Settlement of Indiana as Indicated by the Voting Residences of Certain Elected Officials, John Strietelmeier, Valparaiso University.—The writer is interested in testing 1) whether there is any close correspondence between the distribution of people within a political unit and the distribution of the officials they elect (in this case the governors, senators, and federal representatives elected by the people of Indiana); and 2) whether a series of distribution maps prepared so as to show the cumulative distribution of these officials will disclose any trends in the distribution of the population in general from decade to decade.

He concludes that there is at least a strong tendency for political control to gravitate toward those areas which are numerically strongest and that it is possible to trace with fair clarity the filling up of the state of Indiana by following the movement of its political leaders from decade to decade.

The Present Status and Correlation of the New Albany Shale Flora, J. H. Hoskins and A. T. Cross, University of Cincinnati.—The flora represented by petrified wood fragments found in the New Albany black shale of Indiana and in other similar Devonian-Mississippian deposits in Kentucky, Tennessee and Ohio is much more extensive than generally recognized. The most abundant assemblage of these plants is found in the Falling Run member (Upper Sanderson) of the Lower Mississippian rocks as defined by Campbell. Fewer plant fragments are to be found in the Lower Sanderson and the Underwood and Henryville formations above.

The shales containing this flora lie above those bearing the well-known Callixylon Newberryi which has not been found *in situ* in strata below the Upper Blackiston (U. Dev.) in this region. Additional species of Callixylon are found in the Sanderson.

It is believed that the wood fragments, which are now principally phosphatic, and which are found either in phosphate nodules or as isolated pieces intermixed with them, were concentrated in the bottom deposits of a black mud sea over a long period of time, during which little or no inorganic sediments were accumulating. The source of the vegetation represented by the petrified wood is uncertain, but the greatest concentration of material is on the west side of the Cincinnati arch between New Albany, Indiana and Danville, Ky. The fossil wood is progressively less abundant to the east, at least as far as Irvine, Ky., and to the south into Tennessee around the Nashville dome. One specimen has been recovered from the principal nodule zone as far south as Chestnut Mound, Tenn. A few fragments have been found in the nodules and shale of the rocks equivalent to the Lower Sanderson (Gassaway fm.) as far south as Rowena, Ky.

The species represented appear to correlate rather well to those found in similar deposits of presumed near-equivalent age in Europe, but among them are only a few which may be considered as typically Devonian or Mississippian in range.

Geological Features of the Proposed Cagle's Mill Flood Control Reservoir

PRESTON MCGRAIN

Indiana Flood Control and Water Resources Commission*

The purpose of this paper is to describe some of the geological features of the lower portion of Mill Creek valley and to point out the relationship between the geological phenomena exposed and the use of Mill Creek valley as a flood control reservoir. It is not the primary intent of this paper to justify or criticize the selection of this particular site nor to attempt to point out how it fulfills Lippincott's (2), p. 25) requisite conditions for a reservoir site, but rather to describe the unusual physiographic conditions in what is to be the first flood control project of its kind in Indiana. This report is the result of geological investigations made by the writer during the spring and summer of 1948 in order that a permanent record might be made of the features which are currently exposed in that area.

For a number of years the Corps of Engineers, United States Army, has had under consideration a project known as the Cagle's Mill Reservoir on Mill Creek. More recently funds were appropriated by Congress to begin work on this project. Since this is the first such project under construction in Indiana, tremendous interest has been shown by conservationists, engineers, naturalists, scientists, and others.

Cagle's Mill Reservoir is located along Mill Creek in northwestern Owen and southwestern Putnam counties, Indiana (figure 1). The proposed dam site is located near the east side of the resort and recreation area known as Hoosier Highlands, about two and one-half miles southeast of the confluence of Mill Creek with Big Walnut Creek. Together these two streams form Eel River. The name of the proposed dam and reservoir was transferred from a proposed dam site about one mile downstream from the present location, nearer the old Cagle's Mill. The height of the proposed dam is sufficient to impound water during flood times to the upper falls at Cataract at an elevation of 704 feet. A conservation pool will be maintained for recreation purposes at an elevation of 636 feet. This permanent pool will reach from the dam upstream to the foot of Lower Cataract Falls.

Physiographically, the proposed reservoir area lies in the northern portion of the Crawford Upland of southern Indiana, one of the most rugged sections of the state. However, with the exception of the areas immediately adjacent to the major streams the topography is neither as diverse nor as highly dissected as the area farther south. The more

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* Published by permission of the Chief Engineer, Indiana Flood Control and Water Resources Commission.

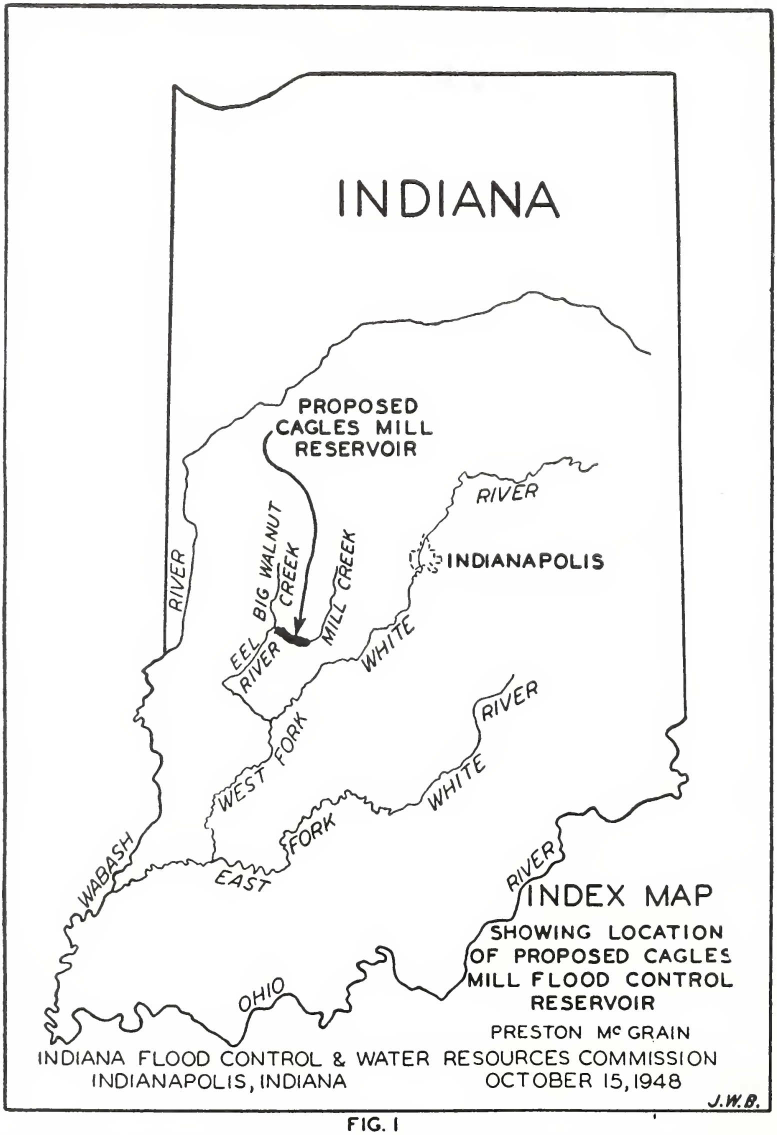

FIG. 1

gentle topography of the lower Mill Creek section of the Crawford Upland is the result of the presence of Illinoian glacial drift and the absence of much of the Chester section which thickens southward and thins northward. The highest hills and ridges are capped with Mansfield sandstone of basal Pennsylvanian age and the deeper valleys are generally cut into middle Mississippian limestones. The oldest exposed rocks are cherty limestone strata of St. Louis age which may be found at the lower falls at Cataract.

Associated with the proposed Cagle's Mill reservoir and encompassing a considerable portion of the watershed of Mill Creek are two glacial lakes which occupied portions of Owen, Morgan, Putnam, and Hendricks counties during Illinoian and Wisconsin times. Thornbury (5) proposed the names Lake Quincy and Lake Eminence for these lakes, presented in detail the early literature bearing upon them, and discussed the results of his own detailed studies as to their areal distribution, origin, and ages. The relationship of Lake Quincy, the western most of these lakes, to the Cagle's Mill Reservoir will be discussed in another paragraph.

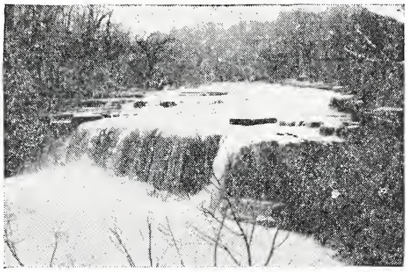

Fig. 2. View of Lower Cataract Falls. The height of the main falls is about 18 feet. Photo by W. T. Powers.

Not only did the glacial lakes attract the attention of the earlier writers but also the two picturesque limestone falls (figure 2) near the village of Cataract, Owen County, have been described and discussed in geological literature on numerous occasions. Thornbury (5), p. 137-140) describes the relation of Cataract Falls to Lake Quincy. More recently Malott (4) presented a detailed study of the stratigraphy of the two falls. The stratigraphic units described and identified by Malott (4) were recognized by the present writer throughout the reservoir area.

Mill Creek rises in western Hendricks County and flows south and southwest across the glacial till and lacustrine plain to Cataract Falls. From Amo in Hendricks County to the top of Upper Cataract Falls, a distance of approximately 35 miles, Mill Creek falls 102 feet or about 3 feet per mile. At Cataract Falls within a distance of a mile, which includes both falls and the connecting rapids, Mill Creek rushes, cascades, and falls about 80 feet from an elevation of 715 feet at the top of the upper falls to an elevation of 635 feet at the foot of the lower falls. From the foot of the lower falls to the proposed dam site, a distance of approximately 8 miles, the drop is but 35 feet or a little over 4 feet per mile. According to planimetric measurements the drainage area of Mill Creek is 375 square miles, 284 of which lie above Hoosier Highlands.

After passing Upper Cataract Falls, Mill Creek encounters a buried bedrock valley which is believed to have been a tributary to the preglacial course of Mill Creek. Here the valley expands greatly in width. Collett ((1), p. 308, Malott ((3), p. 210-211) and ((4), p. 322), and Thornbury ((5), p. 139) recognized the presence of a buried valley in the Mill Creek area but made no attempt to trace it in detail. An excellent exposure of lacustrine deposits was seen in the south bank of a tributary stream in the southwest corner of Section 25, T. 12 N., R. 4 W. The valley narrows again as it approaches the lower Cataract Falls and bedrocks is exposed in the channel and walls of the valley. Here the second bedrock barrier is encountered. From Lower Cataract Falls to the proposed dam site Mill Creek crosses bedrock ridges at numerous points. These exposures vary in expression ranging from small masses barely visible above the water level to hills up to 780 feet in elevation. Near Hoosier Highlands, Mill Creek encounters a bedrock upland mass through which it extends as a gorge for a mile or more. Here the elevation of bedrock on the south side of the creek is 780 feet and on the north side of the creek over 800 feet. The location of the exposures of bedrock and elevations are shown on figure 3. The areas between the partially exposed bedrock ridges and spurs are filled with glacial drift or lacustrine silts or both. Good exposures of these unconsolidated deposits are not common due to rapid weathering, slump, and vegetation and soil coverings. The glacial drift, where exposed, is dominantly till. Boulders and cobbles are present but not abundant. Glacial gravel was observed at three places in abandoned gravel pits. These exposures appear to be parts of a low morainic mass extending in a northwest-southeast direction on the west side of Cagle's Mill reservoir area. The lacustrine deposits consist of thinly laminated calcareous clays, silts, and very fine sands. These sands are described by water well drillers as quick sands. Thornbury ((5), p. 134) traced the lacustrine deposits down the valley of Mill Creek to the village of Cunot in Section 28, T. 12 N., R. 4 W. It was at this point that he placed a morainal dam which caused the ponding of ancient Mill Creek and created glacial Lake Quincy. The present writer has traced the lacustrine deposits still farther downstream thus indicating an early developmental stage of glacial Lake Quincy and a moranial dam somewhat farther downstream than had previously been considered. Excellent exposures of lacustrine silts and sands were observed near the center of the west side of Section 21, T. 12 N., R. 4 W., and in the east bank of a small tributary of Mill Creek in the extreme northwest corner of Section 20, T. 12 N., R. 4 W. The following is a stratigraphic section of the Illinoian deposits observed in the east bank of a small tributary of Mill Creek in the northwest corner of Section 20, T. 12 N., R. 4.W.:

Glacial Drift

Waterlaid glacial sand and gravel—20 feet exposed.

Lacustrine Deposits

Gray and tan laminated, calcareous silt; basal part mostly fine sand in which lamination is indistinct—20 feet.

Gray, laminated, calcareous, sandy clay—4.5 feet exposed to creek bed.

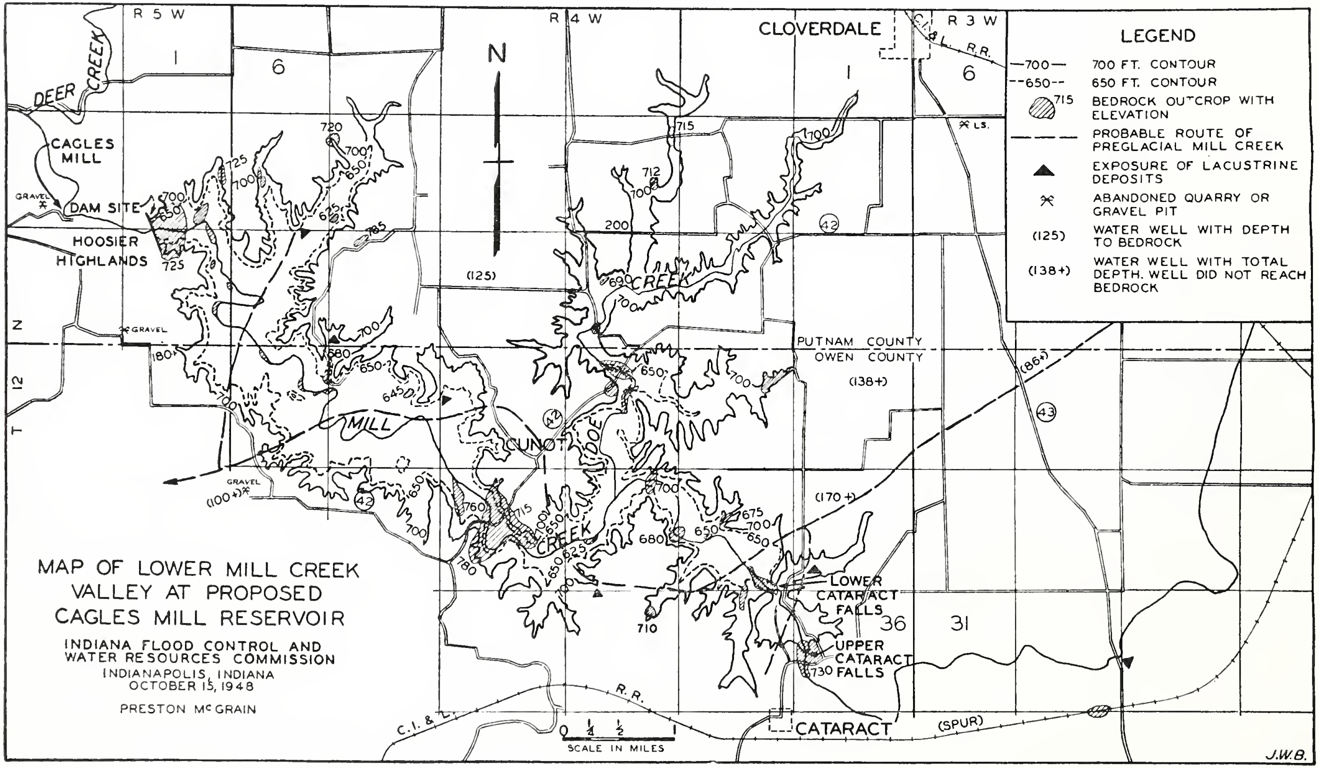
MAP OF LOWER MILL CREEK VALLEY AT PROPOSED CAGLES MILL RESERVOIR
INDIANA FLOOD CONTROL AND WATER RESOURCES COMMISSION
INDIANAPOLIS, INDIANA
OCTOBER 15, 1948
PRESTON McGRAIN
LEGEND
—700— 700 FT. CONTOUR
--650-- 650 FT. CONTOUR
715 BEDROCK OUTCROP WITH ELEVATION
PROBABLE ROUTE OF PREGLACIAL MILL CREEK
EXPOSURE OF LACUSTRINE DEPOSITS
ABANDONED QUARRY OR GRAVEL PIT
(125) WATER WELL WITH DEPTH TO BEDROCK
(138+) WATER WELL WITH TOTAL DEPTH. WELL DID NOT REACH BEDROCK
R 5 W
R 4 W
R 3 W
T 12 N
N
DEER CREEK
CAGLES MILL
DAM SITE
HOOSIER HIGHLANDS
GRAVEL
CLOVERDALE
C.I. & L. R.R.
PUTNAM COUNTY
OWEN COUNTY
MILL
CREEK
CUNOT
DOE CREEK
LOWER CATARACT FALLS
UPPER CATARACT FALLS
CATARACT
(SPUR)
LS.
SCALE IN MILES
0 1/4 1/2 1
J.W.B.

FIG. 3

Other silts were observed in the northeast quarter of Section 18, T. 12 N., R. 4 W., on the end of the spur formed by a south flowing tributary of Mill Creek on the west and a southwest flowing tributary on the east. Beyond this point Mill Creek enters a narrow, bedrock, gorge-like valley and evidence of lacustrine deposits disappear.

A possible route of the former channel of Mill Creek has been indicated in figure 3. This interpretation is based upon field data derived from a study of the physiography of the lower Mill Creek valley and the examination of a number of water well records. The presence of lacustrine deposits, absence of bedrock, and unusual depths to bedrock in water wells were the controlling factors in making this interpretation. It is believed that ancient Mill Creek roughly parallels and lies to the north of the present stream until reaching the vicinity of Lower Cataract Falls. Mill Creek crosses the buried valley just below this falls and apparently again three-fourths of a mile southeast of the village of Cunot in northwestern Owen County. A noticable lack of detailed control occurred at Cunot. In this community domestic water supplies are derived from cisterns and shallow dug wells and, consequently, little bedrock data were available. Three-fourths of a mile west and a little north of Cunot, Mill Creek again intercepted the buried valley and generally followed it until it crossed a bedrock ridge at Mill Creek Valley Camp near the center of the west side of Section 20, T. 12 N., R. 4 W. From this point the buried valley appears to have turned west and northwest. Lack of well data and outcrops have prevented further detailed mapping of its route at this time.

The presence or absence of the bedrock ridges has a very striking effect upon the size and shape of the lower portion of present Mill Creek valley. Where the stream encounters bedrock, even though relatively low in elevation, the valley is narrow and in places even gorge-like. At the proposed dam site only a suggestion of a valley flat exists. (figure 4). At this point Mill Creek exhibits the characteristics of a stream at

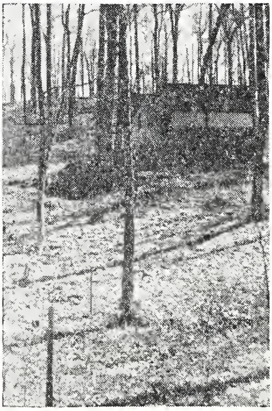

Fig. 4. View looking southwest along the center line of the proposed dam site. Photo by W. T. Powers.

early maturity. Similar conditions exist at Mill Creek Valley Camp, at Croy's Mill southwest of Cunot, at a ridge in the northeast quarter of Section 27, T. 12 N., R. 4 W., and at Lower Cataract Falls. Where the present Mill Creek intercepts its buried ancestorial valley or one of the buried tributaries, the profile assumes the shape of a broad, nearly flat-bottomed "U." The greatest development of this latter valley shape may be seen in Sections 19 and 20, T. 12 N., R. 4 W., immediately upstream from Mill Creek Valley Camp where the valley flat is fully three-fourths of a mile to a mile wide (figure 5). Other striking examples of these broad valley flats adjacent to the narrow bedrock valley were observed about a mile downstream from Mill Creek Valley Camp, immediately below Lower Cataract Falls and immediately below Upper Cataract Falls. From an engineering point of view the V-shaped, rock-walled valleys are most desirable for dam sites and the broad, flat valleys with high walls provide for the storage areas for impounding waters during periods of excess runoff. However, if there are prolonged periods during which the flood pool is high, objectionable leakage might occur through the coarser lacustrine sediments at points where the divides between Mill Creek and the King Creek watershed to the southwest are narrow, such as occurs in the southwest quarter of Section 19, T. 12 N., R. 4 W. As indicated in a previous paragraph, where exposed, the lacustrine deposits consist of thinly laminated calcareous clays, silts, and very fine sand which appear to be of very low porosity and permeability. Local water well drillers reported that this material is unsatisfactory as an aquifer for domestic water supply. Also, the lower portions of the lacustrine deposits were clays, while the sands seemed to be more common in the upper part of the deposit.

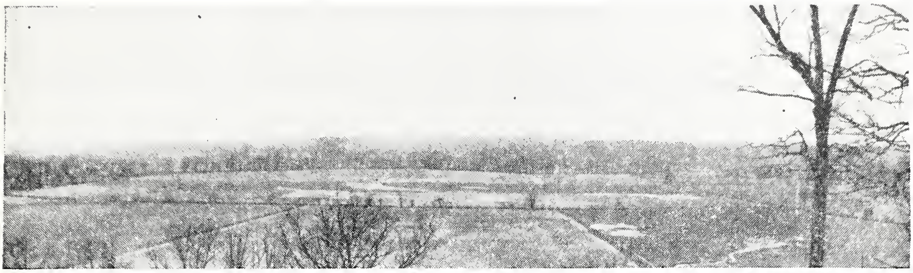

Fig. 5. View of Mill Creek Valley where the present stream has intercepted its buried ancestorial route. Photo by W. T. Powers.

The bedrock stratigraphy of the Mill Creek valley area is relatively simple, however, exposures are not common. Malott ((4), p. 324) gives the following composite section at Upper and Lower Cataract Falls:

Chester

Paoli limestone and shale—17 ft., 6 in. exposed.
Aux Vases calcareous sandstone—3 ft., 9 in.

Ste. Genevieve
    Levias limestone—22 ft.
    Rosiclare calcareous sandstone—23 ft.
    Fredonia limestone—30 ft., 6 in.
    St. Louis limestone—9 ft. 6 in. exposed.

The following is a composite stratigraphic section measured by the writer in gulleys on the south side of Mill Creek near the proposed dam site.

PENNSYLVANIAN

Mansfield
    Fine to medium-grained, massive sandstone; concentration of iron at base—50 ft. exposed.
    Gray shale with many clay iron-stone concretions—0.22 ft.

MISSISSIPPIAN

Chester
  Beaver Bend
    Hard, gray, fine-grained limestone—5 ft.
  Mooretown
    Mostly covered with shows of gray and tan shale—17 ft.
  Paoli
    Single bed of dense, gray to tan limestone with small pyrite crystals; upper 6 inches rather coarsely crystalline limestone—3.5 ft.
  Aux Vases
    Soft, gray shale—1 ft.
    Covered slope—3 ft.

Meramecian

Ste. Genevieve
  Levias member
    Cross-laminated, light to dark gray, oölitic limestone; rests unevenly upon lower limestone strata—10 ft.
    Thin, even-bedded, hard, gray, semilithographic limestone—7.5 ft.
    Tough, gray, rubbly limestone breccia; traces of glauconite—4.5 ft.
  Rosiclare member
    Generally even-bedded, fine-grained, light gray, calcareous sandstone—2.3 ft.
    Cross-laminated, fine to medium-grained, light gray, calcareous sandstone; friable on weathered surface—3.3 ft.
  Fredonia member
    Covered slope—4.5 ft.
    Porous, mottled, tan dolomite—1 ft.
    Covered slope to Mill Creek—5 ft.

Excellent exposures of the upper part of the Ste. Genevieve formation and lowest Chester beds were observed in the very recent excavations for the diversion tunnel of the reservoir on the north side of Mill Creek at the proposed dam site. The interval correlated in the above composite section with the Aux Vases was represented at the intake end of the diversion tunnel by 4 feet of calcareous, blue-gray and green shale with oölitic limestone pebbles and sandstone pebbles and lenses. These Aux Vases beds are underlain by 2 to 3 feet of irregularly brecciated limestone with occasional quartz grains which this writer has recognized as a persistent lithologic facies of the Ste. Genevieve formation thoughout its outcrop area in southern Indiana. A cursory examination of other exposures at the site of the diversion tunnel revealed that other members of the Ste. Genevieve do not occupy their normal intervals at this locality and display a wide variation within short distances. However, these variations should have no influence upon the effectiveness of the proposed dam and reservoir.

According to borings made by the U. S. Army Engineers there is as much as 35 feet of valley fill material in the dam site area.

Prominent exposures of limestone are present in all the gorges listed in a previous paragraph, but the detailed stratigraphy is not always apparent. Unless the Rosiclare or Aux Vases sandy beds are developed and exposed, differentiation of the beds is difficult, as few fossils are present. The Rosiclare has been recognized at Croy's Mill but it is not exposed in either the bedrock ridge at Mill Creek Valley Camp or Cagle's Mill. At Mill Creek Valley Camp the top of the Ste. Genevieve may be identified by the presence of a rubbly, limestone breccia. At Cagle's Mill, one mile downstream from the proposed dam site, the Aux Vases is represented by 1 foot of fine-grained sandstone near the top of the limestone beds. The Rosiclare here is below drainage level.

Although limestone constitutes the biggest part of the bedrock section along Mill Creek, karst features are generally absent. An exception to this is a sink-hole area along Indiana Highway 42 near Doe Creek bridge high above Mill Creek at elevations near 730 feet. The absence of solution features in this normally karsted limestone formation can probably be explained at least in part by the protective cover of lacustrine silts since Illinoian times and the presence of the impervious bed of Pennsylvanian shale which overlies the limestone strata in the western part of the area. This latter feature is particularly well developed in the vicinity of the proposed dam site and has probably aided to a great extent in preventing the limestones from being made cavernous in this locality. Also, since the limestone strata at the dam site were exposed after Illinoian glaciation there has not been sufficient time for the formation of solutional features.

Although the writer has not tried to emphasize the applications of geology to sound engineering practices the facts pointed out in the above discussion cannot be minimized. First, if the present Mill Creek had encountered bedrock throughout its full distance, and not the soft, unconsolidated Pleistocene sediments, the valley would have been narrow, and would not impound sufficient water to justify a flood control reservoir site. Conversely, if this stream had not encountered bedrock the cost of a dam would have been multiplied many times and numerous difficult engineering problems would have been encountered. Thirdly, a protective blanket of Pleistocene and Pennsylvanian sediments has obstructed the downward percolation of meteoric waters into the well jointed and bedded, soluble Ste. Genevieve limestone. Thus, an unusual combination of physiographic and geologic features have produced an area which is probably unrivaled in Indiana for a flood storage reservoir.

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Ground Water Resources of Henry County, Indiana

PRESTON MCGRAIN

Indiana Flood Control and Water Resources Commission*

Introduction

Purpose and Scope. A study of water problems in headwater areas in Indiana led to the study of ground water resources of Henry County. This county derives almost all its water from precipitation which falls within its borders, and ground water is used almost to the exclusion of surface water supplies for municipal, industrial, domestic, and livestock purposes. It is the purpose of this paper to present the results of the survey of these ground water resources.

The present report is preliminary in scope. Field investigations of the ground water resources and geological features of the county were made in the fall of 1947. Heretofore little attention has been given to the geology of Henry County. Since there is a direct relationship between the character of rock formations and the presence of ground water a study of the thickness and important lithologic characteristics of each formation was imperative. The geology of the county as well as an account of the sub-surface water supplies is discussed herein.

Location. Henry County is located in east-central Indiana, approximately half way between Indianapolis and the Indiana-Ohio state boundary. Its length from north to south is 20.0 miles and its width is 19.5 miles. It covers an area of 389.4 square miles according to planimetric calculations. Henry County is bounded on the north by Delaware County, on the east by Randolph and Wayne counties, on the south by Fayette and Rush counties, and on the west by Hancock and Madison counties. New Castle, the county seat, is located approximately in the geographic center of the county, at the longitude of 85 degrees 20 minutes west and latitude of 39 degrees 56 minutes north.

U. S. Highways 35, 36, and 40, and Indiana Highways 3, 38, 103, 109, 234, and 236, all hard surfaced roads cross the county. There are numerous other roads of various degrees of improvement.

The Pennsylvania, New York Central, Nickel Plate, and Chesapeake and Ohio railroads also serve Henry County.

Acknowledgements. In addition to the information collected in the field, numerous persons and publications were consulted for data incorporated in this report. Publications referred to are listed in the bibliography. Many well records and much general information was secured from active and retired well drillers in the area. Well owners throughout the county and several county officials contributed much information regarding water conditions in specific areas. This report would not have been possible without the cooperation of all these people.

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* Published by permission of the Chief Engineer, Indiana Flood Control & Water Resources Commission.

Physiography

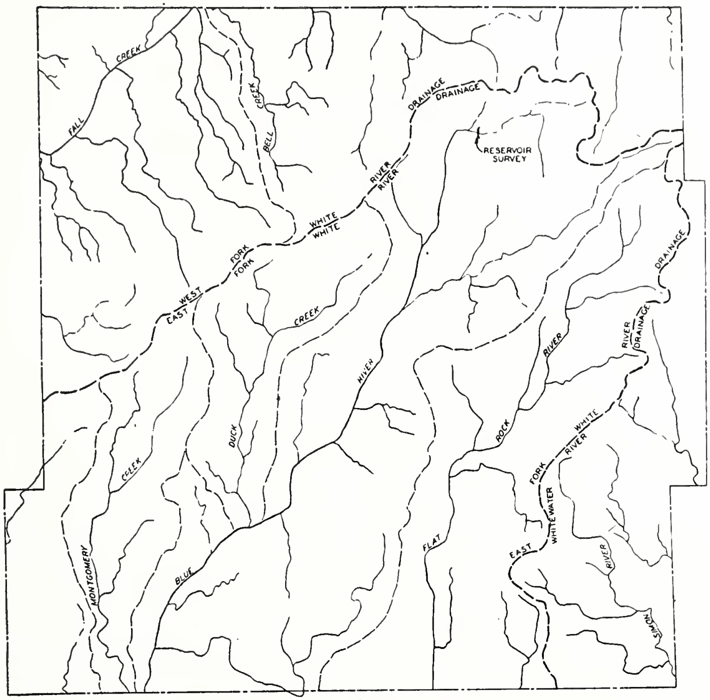
Topography. Physiographically, Henry County lies entirely in the Tipton Till Plain. The Tipton Till Plain, which merges imperceptibly on the south with the Muscatatuck Regional Slope, is characteristically a slightly modified glacial ground moraine plain and over wide areas is monotonously flat. The chief inherent irregularities of the plain are the terminal moraines and their associated features. These are features of glacial construction superimposed on the till plain. Only where the till plain is marked by terminal moraines and where it is cut by troughlike valleys of the main streams does it exhibit a diversified topography. Bedrock exposures are limited to a single small area on Blue River. Elsewhere there lies beneath the glacial drift a diversified erosion surface hidden from view by a considerable cover of glacial drift. It is not unlikely that in preglacial times the relief of this area was comparable to that of parts of southern Indiana at the present time. Well records indicate a maximum bedrock relief of over 500 feet.

Much of Henry County is characterized by glacial morainic belts. In northern Henry County, in the vicinity of Mt. Summit, a system of ridges and knolls rises rather abruptly 75 to 100 feet above the bordering glacial sluiceway near the headwaters of Blue River. This morainic mass is thickly strewn with boulders and is characterized by sloughs and shallow basins between the sharp ridges and knolls. The morainic tracts in southern Henry County are somewhat subdued and are nowhere as prominent as the northeastern area.

A moraine traverses the county from southwest to northeast, passing west and north of New Castle, which constitutes the divide between the East and West forks of White River. On the eastern border of the county there is a moraine with a gently undulating surface which forms the divide between the East Fork of White River and the Whitewater River systems.

The maximum elevation in Indiana centers around an area in the east-central part of the state, which includes part of Henry County. It is reported that the average altitude of Henry County is 1040 feet above mean sea level; this is second only to adjacent Randolph County on the east. The maximum altitude of Henry County is reported to be 1150 feet, the minimum altitude to be 880 feet, and the maximum local relief to be 100 feet (Malott (10), p. 81).

Drainage. Henry County is a headwaters county which lies almost entirely within the drainage basin of the Wabash River. By far the greatest part of the water of Henry County is derived from precipitation within the borders of the county. It is estimated that less than 5 percent of the water fed into Henry County streams is derived from sources outside of the county.



DRAINAGE MAP OF HENRY COUNTY
SHOWING STREAMS WATERSHEDS AND SITE OF RESERVOIR SURVEY
INDIANA FLOOD CONTROL AND WATER RESOURCES COMMISSION
INDIANAPOLIS, INDIANA OCTOBER 15, 1948
SCALE OF MILES
JWB
FIG. 1

Henry County can be divided conveniently into three main drainage areas (figure 1). The largest of these drainage areas is that of the East Fork of White River which covers about 237.3 square miles or a little more than 60 percent of Henry County. The north and northwest tributaries of West Fork of White River drain approximately 101.7 square miles. The remainder of the county, some 40.4 square miles, is drained by tributaries of the Whitewater system which in turn empties into the Miami River northwest of Cincinnati, Ohio.

The Tipton Till Plain, as a constructional feature in the zone of ice wastage, was a plain without valleys, but as the ice melted from the region the older and first exposed portion of it was subject to overflow by the waters coming from the ice of the portion still under construction. Consequently, there are broad valleys leading southward and southwestward across the plain. Most of these glacial waterways are now occupied at least partially by streams, though in all cases very small and feeble compared with their Pleistocene ancestors which, during the melting periods, occupied the whole of the valley and excavated it practically as it is today. Blue River, Flat Rock River, and Fall Creek valleys are valleys which owe their existence largely to the work done by glacial waters. The streams which now occupy these valleys have modified them very little since the close of the glacial period and are but feeble representatives of their mighty progenitors.

The headwaters of Blue River flow into a wide glacial sluiceway on the east side of Section 12, T. 18 N., R. 10 E., about 3 miles northeast of Mt. Summit, and then flow in a south and southwesterly direction in a valley which is approximately one-half mile wide. Buck Creek and part of its tributaries occupy the upper part of this sluiceway and instead of flowing south into Blue River they flow northwest and north to join the West Fork of White River at Yorktown, Delaware County. Similarly, part of Bell Creek (a north flowing tributary of Buck Creek) and the headwaters of Fall Creek occupy a continuous southwesterly trough in western Henry and Delaware counties.

Stratigraphy

The bedrock stratigraphy of Henry County has long been a challenging and puzzling problem. Little can be learned from the poor exposures at the surface, and most well records contain insufficient data from which to accurately determine the bedrock sequence. The following generalized stratigraphic succession is an attempted interpretation of formations encountered based on field observations, information obtained from drillers, and older geological reports.

- Quaternary
  - Recent alluvium—0-30 ft.
  - Pleistocene glacial drift—0-535 ft.
- Silurian—0-200 ft.
- Ordovician
  - Cincinnatian Series—650-785 ft.
  - Trenton limestone—150 ft.
  - *Back River group—320 ft.
  - *Glenwood-St. Peter formations—35 ft.
- *Cambro-Ordovician Series—1330 ft.
  - *Prairie du Chien (Lower Ordovician)
  - *Trempealean (Upper Cambrian)
- *Cambrian
  - *Eau Clair sandstone—610 ft.
  - *Mt. Simon sandstone—320 ft.
- *Pre-Cambrian—30 ft. plus

*After Bieberman and Esarey (1)

Quaternary. The Quaternary includes all the unconsolidated sediments overlying the bedrock surface. These sediments consist of valley inwash deposits which occupy parts of buried bedrock valleys, all types of glacial drift, and fluvio-glacial deposits, all Pleistocene age, and of Recent alluvial materials.

The Recent alluvial deposits in Henry County are confined to flood plains and alluvial fans. They are chiefly sand and silts. No towns and relatively few homes are located in the broad valleys of Henry County streams consequently there is little dependence on the alluvial deposits for water supply.

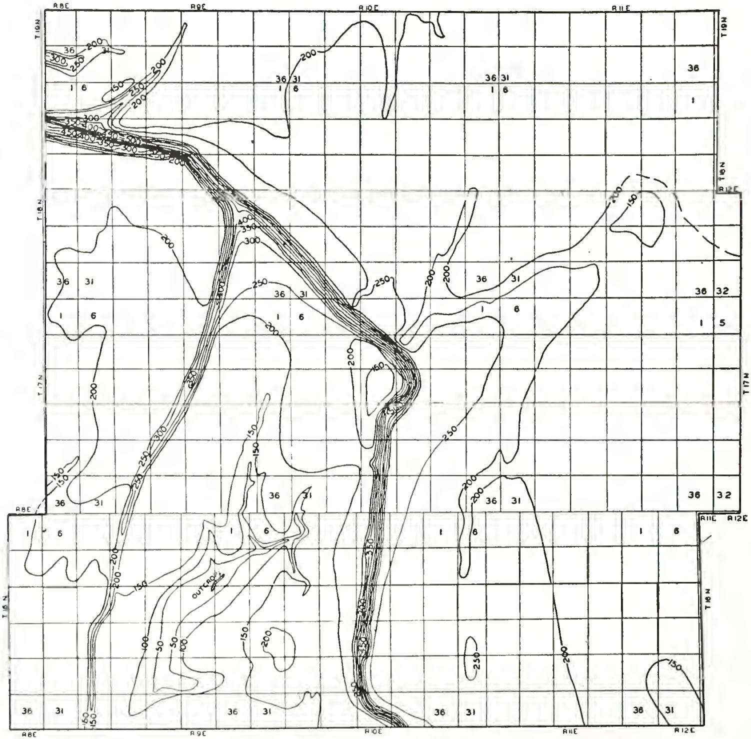
Two periods of glaciation have been recognized in Indiana. In Henry County the Wisconsin drift completely hides the older Illinoian drift which may be interpreted only from well logs and samples. The glacial material may be divided into three general types. The first type is terminal moraine material which is ridge-like accumulations of debris made at the end or edge of an ice sheet, especially where its end or edge has remained stationary for a considerable time. The moraines consist of a heterogeneous mixture of glacial debris varying in size and composition from minute clay particles to massive limestone and granite boulders. With the unsorted drift and till are lenses or pockets of more or less stratified sands and gravels which are interbedded in an uncertain and unsystematic manner. Basins and other depressions between the ridges have often been filled with silt and frequently are marshy or swampy areas.

The second type of glacial deposit recognized in Henry County is ground moraine material. The ground moraine consists of all the drift deposited beneath the advancing glacier and drift deposited from the base of the ice during its recession through melting. The ground moraine is made up of a compact, impervious, clayey material containing scattered sand, gravel, pebbles, and boulders. The till of the ground moraine areas contains more clay and is generally more compact and impervious than the till of the terminal moraine areas, which is more sandy and which sometimes includes isolated permeable masses of gravel. It, like the terminal areas, may be deduced largely from the surface topography.

The third type of glacial material recognized is that deposited by meltwater from the ice. The fluvio-glacial materials in Henry County consist of outwash plains and some valley train-like material which is found principally in the valley of Blue River. The outwash plans are large, relatively flat topographic features constructed of all detrital material swept out of the melting glacier by meltwater streams. The material consists largely of more or less imperfectly sorted and stratified sand, gravel, and silt.

In view of the fact that the Wisconsin is the younger of the two glacial deposits it is the one which is represented by the above glacial materials. The presence of the Illinoian drift is recognized in subsurface investigations by the presence of an old soil or a leached or oxidized zone well below the surface of the ground. (Thornbury (11), p. 45) has indicated that the average depth of leaching of Wisconsin drift in Henry County is 30.3 inches.)

The thickness of the blanket of glacial drift varies from zero (at one locality in the bed of Blue River) to a reported depth of over 500 feet near New Castle (Leverett (7), p. 30) and (Harrell (4), p. 256). Buried bedrock valleys and other irregularities of the bedrock surface account for the unusual thickness. In some of the literature bearing on the problem it has been suggested that the material occupying the "deep drives" in Henry County is composed of glacial drift similar to the materials at the surface, but it is here suggested that these former northward flowing tributaries to the great Teays valley were blocked by the southward advance of the Pleistocene ice sheet and at least partially filled with stillwater accumulations, such as muds and silts, thus forming poor water-bearing material. (The Teays Valley is a high level valley which rose in Tertiary time in the Blue Ridge Mountains in North Carolina, and flowed west and northwest across West Virginia, Ohio, Indiana, and Illinois. It is believed to have dis-



GENERALIZED ISOPACH MAP OF HENRY COUNTY

SHOWING AVERAGE THICKNESS OF GLACIAL DRIFT

ISOPACH INTERVAL 50 FT.

INDIANA FLOOD CONTROL AND WATER RESOURCES COMMISSION

INDIANAPOLIS, INDIANA OCTOBER 15,1948

PRESTON McGRAIN

J.W.B.

FIG. 2

charged into the Gulf Embayment through bedrock valleys now generally occupied by the present Illinois and Mississippi rivers. That portion of the valley in western Ohio, Indiana, and Illinois is buried beneath glacial drift and its route across this area has been traced by means of well records.)

The presence of deeply buried bedrock valleys in Henry County has been suggested in several of the older geological reports on the region and is considered common knowledge among water well drillers in that area. To this writer's knowledge no previous attempt has been made to trace these features or describe their extent in Henry County. Records of over 450 wells were gathered and studied.

An isopach map with intervals of 50 feet showing the average thickness of glacial drift in Henry has been prepared (figure 2). The thickness of the glacial drift is the combined result of the topography of the buried bedrock surface, the amount of glacial deposition, and the depth of subsequent stream dissection. For the purpose of this map all unconsolidated sediments are interpreted as glacial material. The degree of accuracy will vary in different areas with the availability of well data and the local topography. Generally, it is unnecessary to drill much over 100 feet for water in Henry County. No topographic maps of Henry County are available; also, time did not permit a topographic survey in conjunction with this phase of the study. Consequently, the thickness of the glacial drift must of necessity be generalized and considered average for any particular locality. Further, the isopach map is based only on well records in which the location could be determined with some degree of accuracy.

Silurian. Very little is actually known about the bedrock which underlies Henry County's 389 square miles. Bedrock formations come to the surface in the bed of Blue River just south of the bridge at Stone Quarry Mill, 1¾ miles west of Spiceland. The quarries, reported by Kindle ((6), p. 427), have long since been inactive and their location can be determined only by the presence of deep pools or ponds of water north of the bridge and west of the present saw mills. Cumings and Shrock ((2), p. 172) describe rock from one of the quarries, present in the foundation of one of the mills, to be Silurian in age. The present writer believes that this rock and other rock fragments scattered in the vicinity of the abandoned quarries to be partially altered by burning for lime.

Local residents report that stone was exposed for a few hundred yards in the bed of Blue River a short distance below the bridge when this stream was dredged some 15 or 16 years ago. Now, however, alluvial sand and gravel covers most of this area and rock is seen only when the water is low and clear. This stone is a slabby, grayish to tan or light brown, granular, somewhat porous dolomitic limestone. Occasional imperfectly preserved casts of brachiopods represented the only faunal evidence observed. Lithologically this stone resembles some of the beds of Huntington dolomite which outcrops much farther north.

Another opportunity to view the type of stone which might be present beneath the glacial drift in this area is at a stone culvert under the road opposite the northeast corner of the Spiceland School lot. It was reported to the writer that the slabby, cherty, gray limestone used in the construction of this culvert originally came from one of the now abandoned quarries at Stone Quarry Mill to the west. The abundance of chert in these tabular pieces of stone suggest the Liston Creek formation; however, neither the stratigraphic position nor the faunal characteristics could be determined from surface examination of the area.

A few cuttings from a water well at the southwest end of Indiana Highway 3 overpass just west of Dunreith were observed by the writer. These cuttings, which came from the top of the bedrock at a depth of 152 feet, consisted of hard, very fine grained, grayish white, somewhat dolomitic limestone.

Ordovician and Cambrian. No outcrops of Ordovician or older rocks are known to be present in Henry County. In the past many wells have been drilled to the Trenton for gas or oil and, at the present, a few wells in the vicinity of Knightstown are producing small quanities of natural gas.

Bieberman and Esarey ((1), Pl. 1) describe a deep test drilled by the Ohio Oil Company in the SE ¼ of the NE ¼ of Section 12, T. 16 N, R. 11 E., near New Lisbon which was drilled into granite. The total depth was 3670 feet. Limestone belonging to the Cincinnatian Series (Upper Ordovician) was first encountered beneath the 180 feet of glacial drift which blankets that particular area. This extends the previously known areal extent of the Ordovician. Besides the formations of the Cincinnatian Series, the Trenton and Black River limestones, and Glenwood, St. Peter, and Prairie du Chien formations, all Ordovician, and the Trempealean formation and Eau Claire sandstone, Cambrian, were tentatively identified and correlated by Bieberman and Esarey ((1), Pl. 1).

Samples from oil test on the S. L. Roof farm, in the SW¼ of the SW ¼ of Section 18, T. 17 N., R. 10 E., some 4 miles west of New Castle, drilled in 1948, were studied by the writer. In this case the rock was first encountered at 229 feet. No samples of the glacial material were saved. A description of some of the rock encountered follows.

SILURIAN

229-237—White to tan, crystalline, dolomitic limestone.
237-242—Red clayey material; decomposed limestone.
242-252—Light gray, finely crystalline dolomite with chert and glauconite.

ORDOVICIAN

252-257—Soft blue-gray, calcareous shale; "Little Break" of well drillers.
257-272—Gray, very fine grained, dolomitic limestone.
272-325—Soft blue-gray, calcareous shale; "Big Break" of well drillers.
325-363—Gray to white, fine to carsely crystalline, dolomitic limestone and dolomite.

Pre-Cambrian. The above mentioned Ohio Oil Company test near New Lisbon was drilled 30 feet into Pre-Cambrian before being abandoned. The Pre-Cambrian at this point consisted of red granite.

Structure

The regional structure of Henry County is directly controlled by the presence of the northwestern prong of the Cincinnati Arch, which enters Indiana from the southeast. This anticlinal structure, which enters the county from the southeast, is broad and rather flat-topped. Logan ((9), P. 347) reported that the upper surface of the Trenton limestone in the central and southeastern portions of the county is 100 feet above sea level, and is 50 feet above sea level in the northwestern part of the county.

Ground Water

Source and Storage. If the water-bearing materials of Henry County were uniformly porous, permeable, and homogenous, ground water problems could probably be solved by hydraulic data, and the studies of the geologic nature of the water-bearing materials would have been unnecessary. However, as pointed out previously, the materials below the ground in Henry County are heterogenous and their geologic characteristics are varied. It is these variations that control the distribution, quantity, and quality of the ground water. The satisfactory solution of many ground water problems usually involves the putting down of either prospect or test holes, or both, sooner or later.

The formations which underlie the surface of Henry County are saturated with water below a level known as the water table, which ranges greatly in depth. By definition the water table is the upper surface of the zone of saturation in ordinary permeable soil or rock. It is necessary for wells to penetrate the water table if they are to be productive, and even then other factors may prevent the well from being a source of water. The water table is deepest in some of the highest parts of the upland areas and is shallowest in the lowlands. In marshes the water table lies continuously or intermittently above the surface of the ground. The water table does not occupy a fixed position at any given place but fluctuates with rainfall and drouth, being highest just after a period of prolonged precipitation and lowest at the end of a long drouth. The water table has irregularities comparable with and related to those of the land surface, although it is less accentuated. The ground water horizon, if underlain by an impervious layer may be separated from the main body of ground water by an unsaturated or partially saturated rock. The upper limit of a relatively high isolated and local body of saturated material may be referred to as a perched water table.

By far the greatest part of the ground water of Henry County is derived from precipitation within the borders of the county. Practically the whole county is covered from several feet to several hundred feet by glacial drift. Therefore, rainwater which falls on the surface has a chance to penetrate the glacial covering, provided the precipitation is slow and other factors are favorable. In this manner it is believed that precipitation reaches the sand and gravel horizons, the bedrock surface, and the deeper formations. When formations appear at the surface the precipitation has an opportunity to penetrate the strata directly, provided they are porous, and such water may go down the dip of the formations. Similarly, water may move along bedding planes, joints, and other fractures of the rock formations.

Aquifers. An aquifer is a geological formation that transmits water in sufficient quantity to supply pumping wells or springs. An aquifer may be local or widespread. The most important source of water supply in Henry County is from local aquifers in glacial drift. The occurrence of the aquifers in the glacial drift is subject to much variation both locally and regionally. During the course of this survey many reports of the variations in depths of wells came to the attention of the writer. A good example of such a variation is the situation at a group of houses near the junction of Indiana Highways 38 and 234, four miles west of New Castle, where a well, drilled in 1947, is producing water at a depth of 26 feet in glacial drift while neighboring wells had to go 182 to 191 feet to limestone for sufficient water to supply needs for home use.

Water supply in glacial drift will vary depending whether or not the material is glacial till, moraine, or glacio-fluviatile deposits. Wells drilled into till are seldom water-bearing, as till masses are so close textured or so compact that they will not furnish water fast enough to supply the wells. Usually satisfactory supplies must encounter sand or gravel deposits in the glacial drift. In many cases a looser textured bed is found with deeper drilling though in some localities such beds do not exist. If satisfactory supplies are not found in the glacial drift, the well must penetrate the bedrock if the formations are known to be water-bearing.

Lenses and pockets of sand and gravel are the chief water horizons of terminal moraines. Their occurrences in the moraines are uncertain and unsystematic. Therefore, any well drilled in a moraine area must take this fact into account. As in the case of till areas the quantity of water secured from these sand or gravel lenses depends upon their vertical and horizontal extent. The contact between the piled-up terminal moraines and the underlying ground moraine is often an excellent water horizon, especially where deposition of sands and gravels has occurred on top of the ground moraine. Those portions of terminal moraines which consist primarily of boulder clay are low in permeability and yield little water.

Outwash plains composed of water sorted sands and gravels are closely related to the moraines next to which they occur. Such plains are not found adjacent to every moraine or all parts of any moraine. Outwash plains receive much of their water directly from precipitation and from the adjacent moraines by seepage and regular flow of ground water into them. Ground water is found in the coarser deposits of the outwash material usually some depth below the surface.

The contact between the glacial drift and bedrock is frequently an excellent horizon for local water supplies. For some distance along Blue River valley between Greensboro and Knightstown a six-inch bed of coarse, water-bearing gravel occurs at the top of the underlying limestone. It is not to be construed that ground water will be found in all wells at the contact between the drift and the bedrock, for in many cases clay or very fine sand rests on the rock.

In view of the fact that the glacial drift is very thin in the southwestern part of Henry County, especially just northeast of Knightstown, and that the glacial drift interval anywhere in the county may be occupied by clay till and/or very fine sand, it is not an uncommon occurrence to have to search for ground water supplies in the bedrock. The upper portion of the bedrock, particularly that which is in contact with the glacial drift, is often porous and serves as an aquifer satisfactory for domestic water supply. This water is generally potable but salt water was reported to have been encountered in one well in Silurian limestone at the State Epileptic Village north of New Castle. In Wayne and Spiceland townships bedrock wells are common. Municipal supplies for the towns of Knightstown and Spiceland are secured from wells in limestone. Water also occurs frequently in the joints, crevices, and bedding planes of the Silurian limestone.

In the southeastern corner of Henry County and along the bottoms of the deeply buried bedrock channels the shales and shaly limestones of the Cincinnatian Series (Upper Ordovician) occur beneath the glacial drift. Little or no water is present in these strata.

Records of wells into the Trenton formation (Middle Ordovician) indicate that water in that formation is usually salty. An earlier writer, however, reported that some fresh water was found in the Trenton at Knightstown. Artesian flow of fresh water was observed by the writer to be coming from abandoned gas wells near Maple Valley in southwestern Henry County, but the water horizon could not be determined. The town water supply for Shirley on the Henry-Hancock county line is from an abandoned gas test but again the aquifer could not be ascertained since the casing in old wells will deteriorate after a period of years and the water might come from any of several potential water horizons. There is no information on water horizons deeper than the Trenton.

Methods of Recovery. Ground water in Henry County is recovered from springs, dug wells, driven wells, and drilled wells, the latter method of recovery being the most widely used at the present time.

Springs and seeps are usually quite common in morainal areas and Henry County is no exception. Springs are particularly plentiful along the more deeply entrenched streams where the valley has intercepted beds of water-bearing sand or gravel. Such sources of water occur along the valley sides of Blue River, Montgomery Creek, Fall Creek, and Buck Creek. The community of Springport was settled because of the presence of excellent water supply from this source. At the present time an estimated 100 or more small artesian wells and springs provide the local water needs.

The earliest wells in the county were dug by hand usually to a depth of 10 to 30 feet. Generally they were considered adequate at that time but many of these shallow wells did not produce large quantities of water. Water was usually raised by small hand pumps or by buckets.

Driven wells 1¼ to 2 inches in diameter have also been used to secure ground water. This method was often used because an individual could drive a shallow well with little or no assistance. However, the very nature of this method made it impossible to learn much about the nature of the rock materials encountered. Most of the houses in the community of Honey Creek obtain water from 1¼ inch driven wells at a depth of 18 to 26 feet. These wells are reported capable of producing approximately 120 gallons each per hour.

The most widely used method of securing subsurface water in Henry County at the present time is by drilling. Most wells are 4 inches in diameter; however, larger wells, 6, 8, and 10 inches in diameter, are drilled for industrial and municipal uses. Only on the rarest occasion is anything smaller than a 4 inch well currently drilled.

A great many factors over and above the varied geological conditions affect the depth of the well and the amount of water which it will produce. The depth of these 4 inch water wells ranges from less than 30 feet to more than 200 feet. The initial capacities of the wells range from 200 to 900 gallons per hour, generally about 500 to 600 gallons per hour. These tests are considered a minimum rather than maximum capacity. What is considered a satisfactory water supply often is dependent upon the interpretation of the driller on the job and the owner of the well. The determination of a suitable aquifer and satisfactory pumpage varies with the individual. One driller will pass up a water bearing horizon when the sand or gravel will not stand up in the hole, while another driller will use a screen for the same condition. (It should be noted that the use of screens in wells also varies with the individual driller. Some drillers will equip every well with a screen while other drillers will not make a well in a water-bearing horizon if a screen is necessary; the latter contends that a screen may often clog up and the well will require periodic servicing.) In the case of a well in glacial drift, gravel the size of wheat grains is considered minimum requirements for a well. Even though a bed or lens of sand might carry a copious supply of water, sand has a tendency to be carried upward and thus clog the hole. Still other aquifers contain so much fine silt and clay that the water never becomes clean and, consequently, is not satisfactory for domestic use. Wells for water supply for livestock use does not have to meet as strict requirements as those for homes, businesses, etc.

Wells into the limestone of Henry County do not encounter the varied conditions found in glacial sand and gravel; consequently, the personal factor is not as pronounced. Drilling in the limestone is continued until a sufficient quantity of water is reached or until the potential water-bearing formation has been penetrated. Limestone wells are drilled, not dug or driven, and the water is usually encountered in the upper parts of the formation.

No limestone springs occur in Henry County because of the restricted outcrop area. However, artesian flow from wells drilled in limestones is encountered occasionally because the aquifer is fed from a higher elevation.

Local Ground Water Problems. Considerable interest and concern in the subsurface water supply has been shown by the citizens of Henry County in recent years. The writer believes that the concern over the conditions is due primarily to the greatly increased domestic and farm use and the increased suburban and urban population. The advent of the rural electrification program brought in larger, electrical driven pumps and subsequently running water throughout the suburban and farm homes. It is estimated that the household and farm consumption in such cases has been increased at least 3 or 4 times and in some cases up to 20 times. Consequently, the relatively shallow, hand-dug, and driven wells do not meet these increased demands. Also, the capacity of the new pumps exceeds the flow from the shallow aquifer. In these cases drilled wells have been necessary to supplement or replace the dug wells. Local residents informed the writer that there has been an increase during the past few years in livestock. This, in turn, has increased the demand for water. A third factor that has stimulated water well drilling in recent years is the concentration of home building in suburban areas out of reach of municipal supplies. The deepening of drainage lines and construction of new drains has undoubtedly lowered the water level in some shallow wells. However, it is believed that many of these wells would not meet the current increased demand for water had other factors remained unchanged. Increased runoff due to deforestation has possibly had minor influence upon the water table but this loss probably would not equal the greatly increased consumption. Recession of a water table may be caused also by decrease in precipitation. Although no records have been kept within this area as to the relationship of rainfall to the ground water level, the fact that less than 5 per cent of the water fed into the Henry County streams is derived from sources outside of the county indicated how closely the water supplies are dependent upon precipitation.

Local ground water supplies in the New Castle area appear adequate for individual suburban wells. However, the prospects for the city for the future are not as promising. If the city continues to grow as rapidly as it has during recent years the present municipal and industrial water supply may have to be supplemented by a surface reservoir or wells located some distance from the city. The same is true, but to a lesser extent, for Knightstown.

Conclusions

Henry County is a headwaters area which depends almost entirely upon precipitation within the bounds of the county for a continual supply of surface and subsurface waters. Municipal, industrial, domestic, and livestock water supplies are derived almost entirely from ground water sources. The principal source of ground water in Henry County is local aquifers in the thick mantle of glacial drift which blankets more than 97 per cent of the county to a depth of 100 feet or greater. Where the glacial cover is thin or composed of impervious clay till, domestic and agricultural supplies of water may be obtained from Silurian limestones and dolomites which underly most of the county. Water in these rocks usually occurs in the upper 20 to 30 feet of the limestones. Geological formations older than Silurian can not be relied upon to yield adequate potable water supplies. Shales and shaly limestones of the Cincinnatian Series (Upper Ordovician), immediately under-lying the Silurian limestones and dolomites, are neither porous nor permeable and, consequently, do not make satisfactory aquifers. The Trenton limestone (Middle Ordovician) frequently yields copious quantities of water, but in general this water is highly mineralized.

It is thought that no actual over-depletion of ground water reserves exists as yet for Henry County as a whole. Ample supplies of water for domestic and agricultural purposes may be secured below a depth of 40 to 50 feet. Municipal and industrial supplies, particularly in the New Castle Area, may have to be derived from wells located some distance from that city or from surface supplies resulting from the construction of a dam and reservoir. Excellent water-bearing gravels are known to exist along Duck Creek about 4 miles a little north of west of New Castle's pumping station.

Local recession of the ground water level in Henry County is believed to be the result of a combination of several factors, the foremost of which is the greatly increased consumption of water for domestic, industrial, and agricultural purposes.

Buried bedrock valleys are known to exist in Henry County. From data gathered in the field and our knowledge of other buried valley systems in Indiana, it is postulated that the buried valleys in Henry County are tributaries of the great Teays system which once crossed northern Indiana from east to west. Wells drilled for water along these valleys in Henry County have not encountered satisfactory supplies of water. The character of the material encountered in these tests suggests that the valleys were blocked by the advance of Pleistocene ice and subsequently were filled with fine silts and clays which are neither sufficiently porous nor permeable to yield ground water consistently.

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Underground Water and Glacial Geology of Scottsburg, Indiana and Vicinity

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Introduction

Early in July 1948 the writer was asked to assist the firm of Poole and West, well drillers, of Scottsburg, Indiana in a search for a larger water supply for the city. The project as proposed by the city required the contractors to provide a well or wells that would furnish 400 gallons per minute of potable water. These wells to be located within five (5) miles of existing water mains.

It is the purpose of this report to record the results of this study including the results of borings made and secondly to describe something of the glacial geology of this part of the Scottsburg Lowland.

Previous Work

In April of 1945, Mr. Fred H. Klaer Jr. of the U.S.G.S. published a "Preliminary Report on Ground-Water Conditions in the Vicinity of Scottsburg, Scott County, Indiana." This report summarizes the "results of several days field investigation" as well as work previously done in an effort to add to the city's inadequate supply of water. The inadequacy of the water supply may be judged from Klaer's statement, "The total quantity of water available was estimated to be 130,000 gallons per day. The average daily consumption in September of 1944 was 172,000 gallons per day with a maximum of 200,000 gallons per day."

The most extensive drilling done in the past was by the Layne-Northern Company of Mishawaka, Indiana. In 1938 this company drilled 41 test wells on which accurate logs were kept and numerous tests were recorded without preserving the logs. Most of the logged wells were put down in the vicinity of Lake Iola at the northern edge of the city but a few were drilled elsewhere which contributed considerably to an understanding of the bedrock topography.

The Present Study

The present study was undertaken with the following assumptions in mind. (1) The Scottsburg Lowland[1] was carved by glaciation. (2) During deglaciation, water from the shrinking ice sheet should have established fairly definite channels in the bedrock, and these channels would have fairly extensive permeable sediments. (3) Since the lowland of the vicinity of Scottsburg is roughly six miles wide, a major stream could be assumed to have done the carving. Its channel sediments would be permeable, extensive and sufficiently continuous to make an aquifer.

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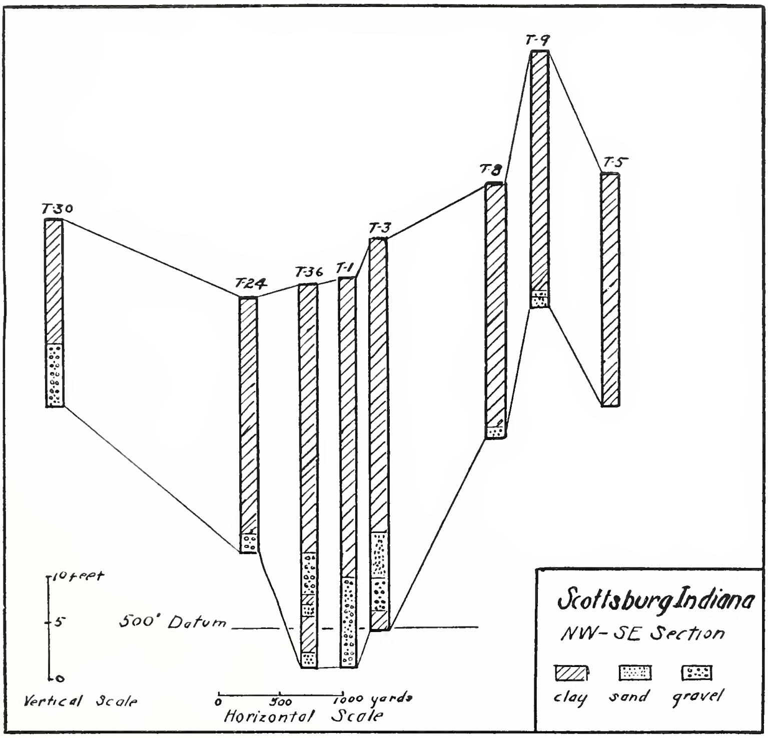
[1] For description of this physiographic division see: "Handbook of Indiana Geology" Pages 80-90. Indiana Department of Conservation 1922.

On the other hand, if such permeable, extensive, and continuous sediments did not exist there was no point in looking for lesser sand and gravel bodies since they could not be expected to yield the 400 gallons per minute of water required by the contract.

Thus the problem resolved itself to a matter of making soundings in the glacial drift in a pattern sufficiently close to encounter any extensive gravels filling a bedrock channel[2].



As a preliminary to this search, the logs of the Layne-Northern Company were studied and two sections made. One trending NE-SW and a second NW-SE as shown in figure 1. These revealed a low in the vicinity of Test T-1.

Just prior to the writers employment on this project Poole and West had recognized this low and had sunk three wells at points marked W2, W3, and W4 on the accompanying map (figure 2). These wells filled with water but, on pumping well W2, the static head was lowered 23 feet and that of well W4 lowered 4 feet. Both wells required three days to recover a normal static level. This slow recovery discouraged further sounding close to the wells since the sand body encountered, though thick enough, could hardly be extensive in view of this rapid drawdown and slow recovery.

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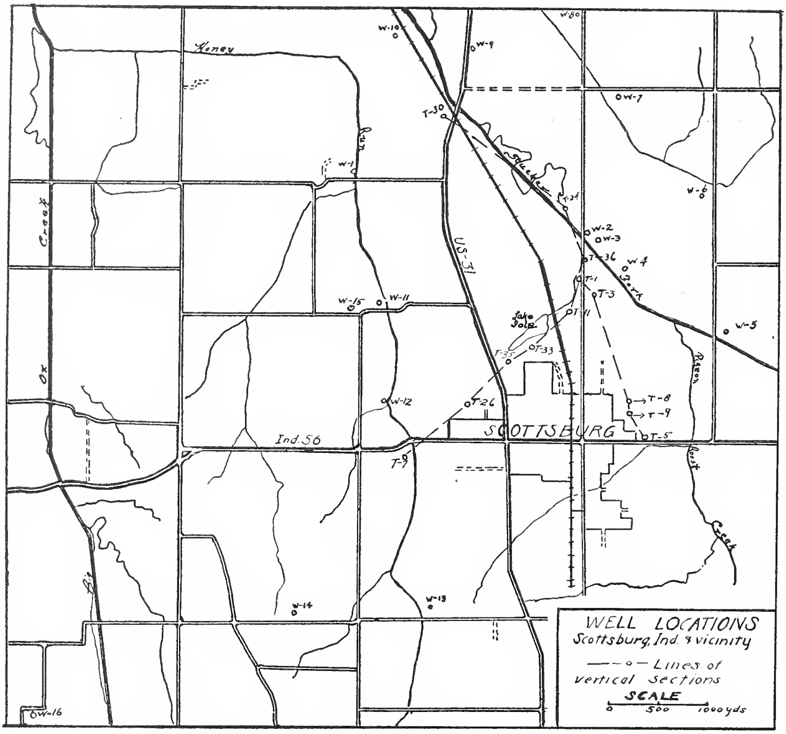
[2] Deep drilling in bedrock was not considered advisable due to the high mineral content of waters usually encountered.



Nevertheless, the valley of Stucker Fork was explored with borings at W-5, 6, 7, 8, 9, 10 (figure 2). These together with Layne-Northern Co. Tests, T-23, 24, 29, 30, 36 proved Stucker Fork did not have an extensive aquifer

Attention was next directed at Honey Run. Beginning in sec. 12, 6E. 3N. tests were made up stream as shown in figure 2. at W-1, 11, 12, 13, 15. None encountered any considerable sand except W-11 which filled with sand and water at 13 feet below surface. This hole was "mudded back" and by keeping a head of water in the hole 3½ feet of water bearing sand was penetrated and 5½ feet deeper bedrock was encountered,—see accompanying logs. Test W-15 sunk 200 yards away penetrated clay and clay only. Other borings in Honey Run yielded similar negative results as did Layne-Northern well T-25.

Thus the stream valleys were eliminated as likely water producers and the uplands were prospected. Borings were made at W-14 sec. 25, 6E. 3N. and at W-16 sec 35, 6E. 3N. neither showed pervious beds. A permanent well of the city T-46 sec. 18 7E. 3N. bottoms on bedrock and yields only a small quantity of water. Tests of Layne-Northern Co. T. 26 (western part of city) and T-40 south of city encountered nothing but clay and were dry.

This evidence was deemed sufficient to eliminate the area beneath the divide as a water bearer and boring was discontinued.

Bedrock Topography

The bedrock in the southwestern part of this area is a gray shale (Borden) the rest is black shale (New Albany). Though both are commonly described as soft shale they are too hard to be cut with an auger. Hence, borings penetrated only to broken rock.

It is possible to contour the bedrock from the 57 borings on which records exist. The Stucker Fork floodplain overlies an elongated bed-rock low with an embayment in the vicinity of Lake Iola. This embayment is the only place where thick sand lenses are encountered.

Glacial History

The region has had two periods of deposition with an interval between during which plant growth flourished,—wood was brought up from test 9,—and others showed a weathered clay with carbonaceous particles at varying depths usually about 6 feet below the surface. The thickness of this weathered peaty zone was usually less than a foot though test W-9 penetrated 3 feet of plant debris and tests W-13 and W-14 had 2 feet of peat and clay. The accompanying logs show the record for all the above.

The hypothesis of a major glacial stream in the Scottsburg Lowland seems untenable for no extensive sand and gravel bars exist. The Lake Iola embayment in the bedrock has a thick sand body (15 feet) but it is not extensive and not continuous.

In view of this lack of evidence of glacial streams it would seem that a glacial rather than a glacio-fluviatile origin of the lowland must be assumed. A possible explanation is found in the adjacent "Knobs" to the west. These "Knobs" (knobstone escarpment) resisted passage of the ice across them and tended to alter the direction of ice movement to parallel their front. Thus the erodable shales adjacent to the "Knobs" were subject to a more severe ice attack than similar shales farther east and hence were more deeply eroded. The bedrock low beneath Stucker Fork may not even be continuous but merely a local variation in rodability of the shale.

The origin of the clay which covers this area and so much of the adjacent Muscatatuck Regional Slope to the east is not clear. Leverett[3] maps this area as loess and such may be the best designation for the material. Nevertheless; it should be borne in mind that columnar jointing, and weathering in vertical cliffs is not present. Nor have land fossils been discovered in the clay.

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[3] Leverett, Frank. "Pleistocene of Michigan, Indiana and History of the Great Lakes." Monography of U.S.G.S. Vol. LIII, 1915. Plate VI.

Summary

A study of the results of nearly 60 wells and borings made in a search for water in the vicinity of Scottsburg, Ind. shows clay covering the bedrock with only a few scattered, discontinuous, thin sand lenses. Thickness of the clay varies from 0 to 40 feet.

An elongated depression in the bedrock exists beneath the Stucker Fork floodplain trending NW-WE. With a conspicious embayment at Lake Iola.

There are a few widely scattered sand lenses but no other evidence of glacio-fluviatile origin. The origin of the lowland itself at this locality is believed to be due to diversion of ice by the adjacent knobstone escarpment which accelerated glacial action in the soft shales of the lowland. Whether the clay which covers the bedrock is wind or water laid or a weathering product is not determined. That there have been two periods of deposition separated by a period of plant growth and weathering is evident.

Log of Test Wells Drilled and Borings by Poole and West

Scott County, Indiana, July, 1948.

Test: W-1 **boring**

Location: Range 6E. Twp. 3N. Sec. 12; 1750 yds. E. 5 yds. N. of SW corner.

Bed of Honey Run
Surface el. 532 ft.

Formations	**Thickness Ft.**
Gravel	2½
Blue Clay	8 and more

Test: W-2 **well**

Location: Range 7E. Twp. 3N. Sec. 17; 505 yds. E. 1300 yds. N. of SW corner.

Surface el. 536 ft.

Formations	**Thickness Ft.**
Clay	13
Sand, Blue Clay	16
Gravel, Sand, Shale	7
Bedrock	—
	Total 36

Test W-3 **well**

Location: Range 7E. Twp. 2N. Sec. 17; 645 yds. E. 1285 yds. N. of SW corner.

Surface el 536 ft.	**Thickness Ft.**
Formations	13
Clay	16
Clay and Sand	7
Gravel	3
Clay	—
Bedrock	Total 39

Test W-4 **well**

Location: Range 7E. Twp. 3N. Sec. 17; 830 yds. E. 880 yds. N. of SW corner.

Surface el. 536 ft.

Formations	**Thickness Ft.**
Clay	13
Sandy Clay	16
Gravel	7
Bedrock	
	Total . . 36

Test W-5 **boring**

Location: Range 7E. Twp. 3N. Sec. 16; 30 yds. E. 240 yds. N. of SW corner.

Bed of Stucker Fork

Surface el. 532 ft.	**Thickness Ft.**
Formations	1½
Blue Clay	10
Muddy Sand	3
Sandy Clay	½
Clay and Broken Shale	
	Total . . 18

Test W-6 **boring**

Location: Range 7E. Twp. 3N. Sec. 17; 1720 yds. E. 1580 yds. N. of SW corner.

Surface el. 536 ft.

Formations	**Thickness Ft.**
Yellow Clay	7½
Blue Clay	2
Yellow Clay	½
Blue Clay	9
Dark Clay and Shale	½
Bedrock	
	Total . 19½

Test W-7 **boring**

Location: Range 7E. Twp. 3N. Sec. 8; 850 yds. E. 840 yds. N. of SW corner.

Formations	**Thickness Ft.**
Yellow Clay	7
Peat	½
Blue Clay	12
Dark and Gray Sand	2
Sand and Broken Shale	½
	Total . . 22

Test W-8 **boring**

Location: Range 7E. Twp. 3N. Sec. 8; 400 yds. E. 1640 yds. N. of SW corner.

Surface el. 538 ft.

Formations	**Thickness Ft.**
Clay	19
Sand	½
Broken Shale	
	Total . . 19½

Test W-9 **boring**

Location: Range 7E. Twp. 3N. Sec. 7; 1130 yds. E. 1300 yds. N. of SW corner.

Surface el. 532 ft.

Formations	**Thickness Ft.**
Yellow Clay	4
Blue Clay	14
Sand Peat and Wood	3
Brown Clay	3
Gravel, Broken Shale	2
	Total 26 (Limit of Boring)

Test W-10 **boring**

Location: Range 7E. Twp. 3N. Sec. 7; 350 yds. E. 1350 yds. N. of SW corner.

Surface el. 534 ft.

Formations	**Thickness Ft.**	
Yellow Clay	5	
Blue Clay	21	
Total	26	(Limit of Boring)

Test W-11 **boring**

Location: Range 7E. Twp. 3N. Sec. 18; 230 yds. E. 490 yds. N. of SW corner.

Surface el. 538 ft.

Formations	**Thickness Ft.**	
Yellow Clay	6	
Peat and Clay	½	
Blue Clay	6	
Coarse Sand with Water	3½	(hole "mudded
Blue Clay	3	back to
Clay and Sand	2½	penetrate)
Bedrock		
Total	21½	

Test W-12 **boring**

Location: Range 7E. Twp. 3N. Sec. 19; 210 yds. E. 1325 yds. N. of SW corner.

Surface el. 548 ft.

Formations	**Thickness Ft.**
Clay	18
Broken Shale	½
Total	18½

Test W-13 **boring**

Location: Range 7E. Twp. 3N. Sec. 30; 670 yds. E. 930 yds. N. of SW corner.

Surface el. 565 ft.

Formations	**Thickness Ft.**
Clay	5
Clay and Peat	2
Clay	6½
Sand	3
Blue Clay and Shale	½
Total	17

Test W-14 **boring**

Location: Range 6E. Twp. 3N. Sec. 25; 1405 yds. E. 920 yds. N. of SW corner.

Surface el. 594 ft.

Formations	**Thickness Ft.**
Clay	8
Clay and Peat	2
Blue Clay	7½
Clay and Broken Gray Shale	½
Total	18

Test W-15 **boring**

Location: Range 7E. Twp. 3N. Sec. 18; 360 yds. E. 480 yds. N. of SW corner.

Surface el. 548 ft.

Formations	**Thickness Ft.**
Clay	11
Broken Gray Shale	
Total	11

Test W-16

Location: Range 6E. Twp. 3N. Sec. 35; 315 yds. E. 1755 yds. N. of SW corner.

Surface el. 616 ft.

Formations	**Thickness Ft.**
Clay	4
Clay and Peat	1½
Blue Clay	5½
Sand	1
Clay	15
Clay and Broken Shale	9
Total	36

Rainfall Variability

RONALD L. IVES, Indiana University

Introduction

Monthly and annual rainfall are not only not the same in all places, but vary from year to year in a single location. Where the annual variation is not great, as in Indiana, biotic forms and human culture, being somewhat flexible, are able to compensate for most of the variations. Where the variation is great, or the local environment is being worked close to theoretical limits, extensive compensatory mechanisms must be set up, or each deviation of the rainfall from the optimum value produces great biotic and economic hardship. Prior to about 1940, Indiana had land to spare, so that rainfall variability was of academic interest only to all except a few specialized engineers. Today, and probably for all of the foreseeable future, with increasing production costs, and continuing world-wide food shortages, demand for Indiana farm products is increasing, and at the same time present supplies of agricultural and municipal water are being crowded. In consequence, for the average resident of Indiana, rainfall variability has acquired, or will shortly acquire, a definite personal importance.

Rainfall variability is not only not shown, but is effectively concealed, by the standard climatic charts, which customarily show mean monthly temperatures and precipitation, usually computed for "the life of the record," which, at many stations, is more than half a century. Despite this omission, these charts are extremely useful indicators of average conditions. Charts for four stations—Yuma, Arizona; Salt Lake City, Utah; Bloomington, Indiana; and New York City, N. Y., comprise figure 1. Quite obviously, agriculture in Yuma will be productive only of tumbleweeds and guayule unless irrigation is used. By diversion of almost the entire flow of the Colorado River, the once-arid Salton Sink, west of Yuma and climatically similar, has become the fertile and productive Imperial Valley. Similar procedures, but less extensive, have made the Salt Lake area highly productive.

Reference to the Bloomington chart shows that irrigation is not necessary, for most crops, in a statistically normal year, for not only is rainfall plentiful, but it is fairly well distributed through the year. A slight increase in the production of some crops might be possible if a portion of the normally high rainfall of March and April were stored for use during the comparatively dry month of July. Whether such storage is economically desirable under present conditions is questionable.

The mean rainfall shown in these charts is the ordinary average, computed by adding a number of rainfall values, and then dividing the sum by the number of values added. As is well known to meteorologists

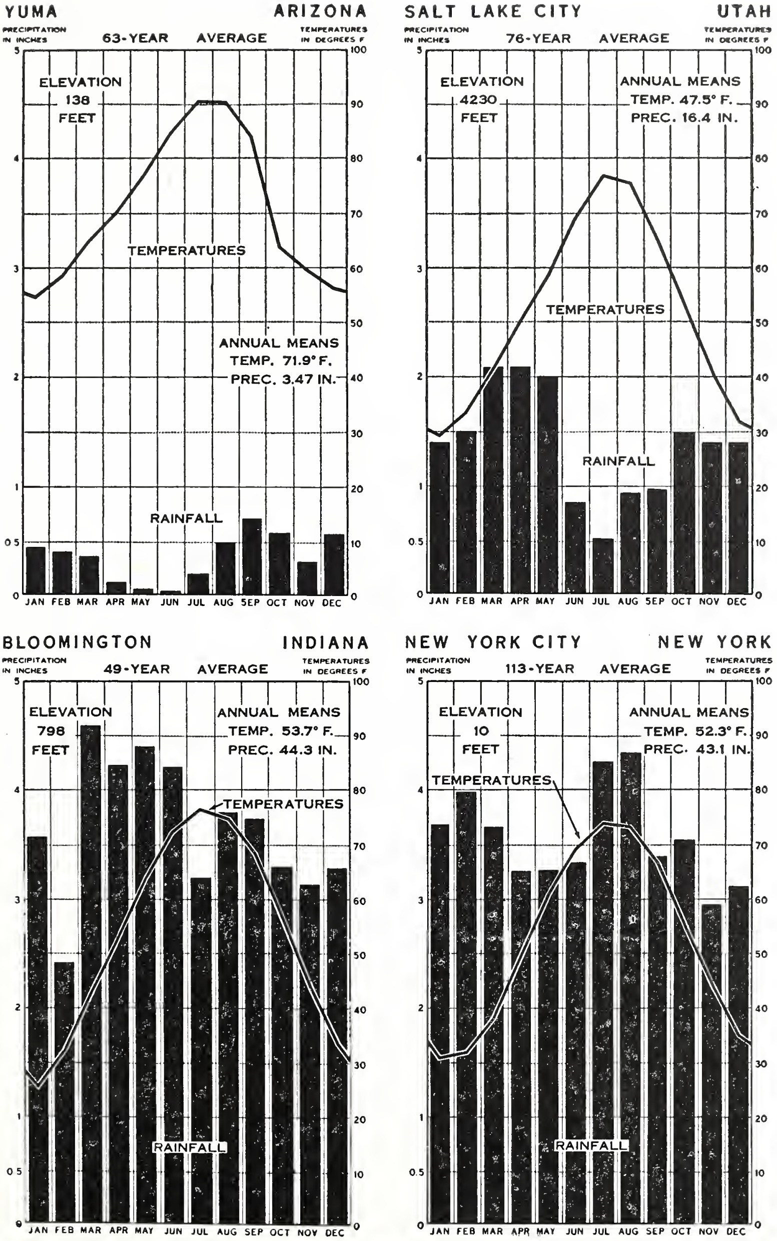

Fig. 1. Climatic charts for Yuma, Arizona; Salt Lake City, Utah; Bloomington, Indiana; and New York City, N. Y.

and climatologists, the mean value, which is also known as the normal, or average, is the value least commonly recorded at many stations.

Rainfall Variability

Rainfall variability, which is not shown on conventional climatic charts, may be of greater biotic and cultural importance than the mean value of the rainfall. If the rainfall in a given area is consistent enough so that each annual planting at least "returns its seed," then a relatively simple cultural organization is possible. Such has been the case in most parts of the "corn belt" of the United States. If, however, rainfall is so variable that a crop is successful only one year in four or five, then a sedentary population must adopt a much more complicated culture, able to store either seed or water, or both, to insure survival through several dry years. In ancient times, the inhabitants of the dry southwest stored seed for long periods; today, water is stored in a series of complicated and expensive reservoirs.

An alternative to the storage of seed or water, or both, is migration over a large area. This is fairly successful where rainfall is erratically distributed, and was used for many generations by the Pima-Papago Indian groups in Arizona and Sonora. Planting of fast-maturing crops was done immediately after a rain, in an area where soil moisture was retained. This "temporale" agriculture, still used in parts of Sonora, is rather surprisingly productive, but is suitable only for areas of low population density.

A "horrible example" of rainfall variability is shown by the Yuma, Arizona, rainfall record, comprising figure 2. Here, the rainfall in some

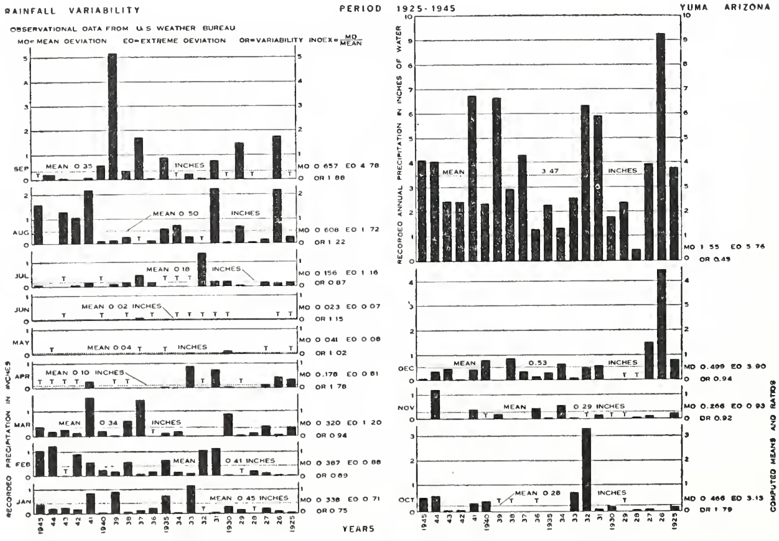

Fig. 2. Monthly and annual rainfall at Yuma, Arizona, for the period 1925-1945 inclusive. Rainfall variability here is extreme.

months (occasionally all from a single "cloudburst") exceeds that for some years. In some years here, without irrigation, even a cactus crop would fail: in others, the cacti would be washed away. Variability at other stations (figure 1) is markedly less[1] the regularity of the rainfall, *in general*, becoming greater as the annual total increases.

Measures of Variability

Rainfall variability may be measured in a variety of ways, most of which have definite and specific uses; none of which fit all needs. Simplest method is to record the actual rainfall at a station, and then to determine the deviation of the recorded value from the cumulated mean for that station. This method is followed by the U. S. Weather Bureau in the preparation of the monthly and annual *Climatological Data* sheets for the various sections.

Although the actual deviations, or the mean of these deviations ("Mean deviation") are of considerable local value, their general value and significance are slight, for an annual deviation of four inches is likely to be disastrous in Yuma, Arizona, for example, but of little significance in Bloomington, Indiana. Several areal studies suggest that mean rainfall deviations are more uniform than mean rainfalls.

In addition, most life forms, upon which our culture and existence are ultimately dependent, can tolerate a considerable variation in water supply, but this variation is commonly a factor of the optimum for that form. Its value depends upon the specific crop, but is commonly from 1.1 to 1.5.

In consequence, the most useful simple measure of rainfall variability is the variability index, computed by dividing the mean deviation in rainfall at a given locality by the mean rainfall for the same locality.

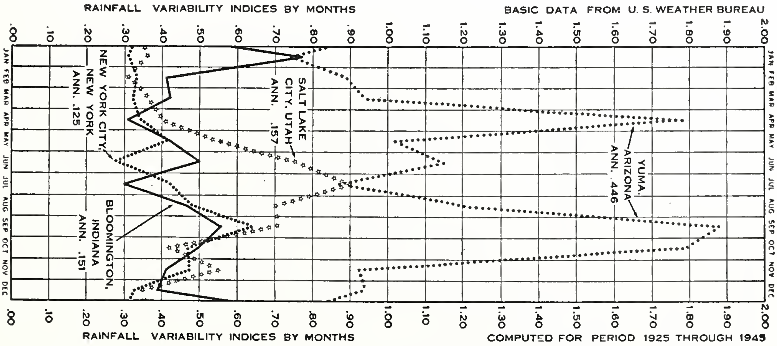

Fig. 3. Rainfall variability indices for Yuma, Arizona; Salt Lake City, Utah; Bloomington, Indiana; and New York City, N. Y.

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[1] Variability at Salt Lake City is discussed in Ives, R. L., Inter-relations of Terrain, Weather, and Climate in the Southern Salt Lake Desert, forthcoming; and that for Boomington, Indiana, is described in a paper being prepared by M. W. Wise, of Indiana University.

Variability indices, computed on this basis, for the four stations graphed in figure 1, are shown in figure 3. With present records and rainfall regimes, this index seems most suitable for extensive studies of rainfall variability.

Where agricultural production depends not only upon immediate rainfall, but also upon some "delayed" factor, such as filling of a reservoir, recharge of an aquifer, melting of snow, or saturation of a subsoil component, simple month-by-month variability indices may not be adequate, and some cumulative system will be found useful. Simplest of these systems is computation of the mean deviation of the rainfall cumulative from a given date, such as Jan. 1 of the year concerned. Many actual problems are even more complex, calling for use of an attrition formula, having the general form K log B, in which both B and K are compound factors, determined from study of local conditions. Comparison of the simple variability index, computed on a monthly basis, with an index computed from values cumulated since Jan. 1, for Bloomington, Indiana, for the period 1925-1945, is included in figure 4. It will be noted that where the rainfall is, or can be, cumulated, by any means, until late spring, the variations in the cumulated amount, and hence in the amount of water available during the growing season, are greatly lessened.

Forecasting Possibilities

In a very general way, it can be stated that in two thirds of the years in any given long sequence (20 years or more), the rainfall will be within the limits of the mean plus the mean deviation, and the mean minus the mean deviation. This approximation is valid for most locations in North America, its dependability declining as the rainfall variability index increases. Theoretically, by use of the Pearsonian *coeffcient of variability*[3], rainfall variations could be evaluated on an actuarial basis, making possible more effective crop insurance at lower cost. Such a coefficient of variability, computed for Bloomington, Indiana, for the period 1925-1945, is shown in figure 4. It will be noted that this is slightly greater than the variability index, previously computed. The difference is caused by the squaring of the deviations, a procedure which gives greater emphasis to larger deviations.

Where the "population" is stable, and the distribution curve is only moderately skewed, the probability of any amount of variability can be determined to any accuracy desired. Most unfortunately, we have no assurance that the "population" (in this case climate) is stable, and much reason to suspect that it is subject to a number of cyclical variations, complicated by fluctuations that now appear to be "pure random." Some progress has been made in correlating climatic fluctuations with sunspot cycles, and integral multiples of the sunspot cycle

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[3] Derivation of these indices is outlined in "Formulae" at the end of this paper.

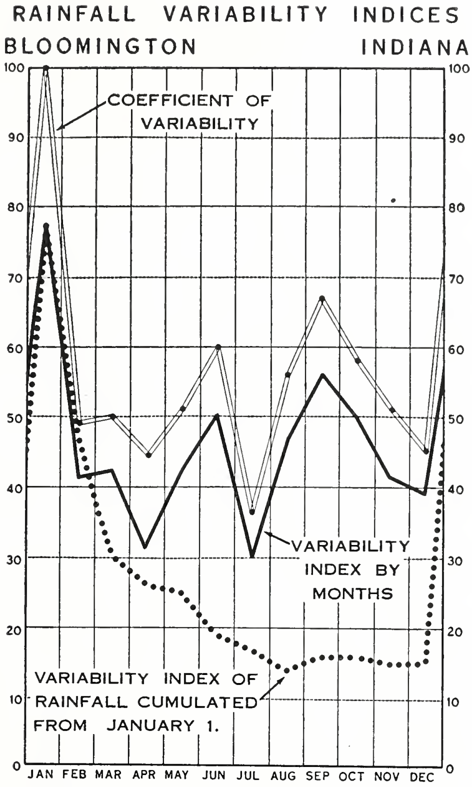


Fig. 4. Comparison of various rainfall variability indices.

(roughly 11 years). Other workers have demonstrated that rainfall in some areas (and only in some areas) bears a definite relation to the solar radiation incident some time previously, not always in the area under consideration. After all of the known and suspected cyclical variations are accounted for, there are still "gremlins" in most rainfall distribution curves. These must be accounted for before rigorous mathematical procedures can be applied to rainfall forecasting.

In addition to the above, most rainfall curves are immoderately skewed, with the absolute maximum value being many times the mean. Not only is the rainfall inconstant, but the amount of skew is not fixed, so that ordinary statistical methods cannot be applied to the problem with any confidence.

Because of the shifting of mean values, use of the standard deviation, and of the Pearsonian coefficient of variability, is not advisable. In contrast, with a slowly shifting mean, values determined by computation of the variability index, in which the deviations are not squared, remain valid for a considerable period, and the errors introduced by slow shifts of the mean cancel out, in time, particularly if the shiftings are of a cyclical nature.

Scatter of the annual values, for the period 1900-1948, for Bloomington, Indiana, is compared with variously computed means in figure

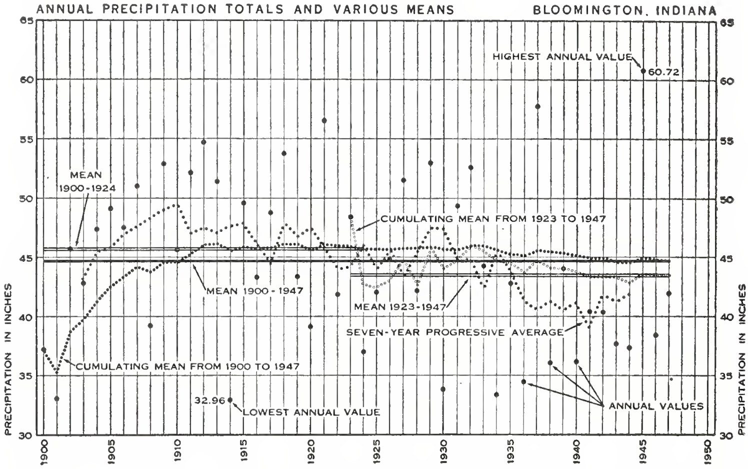


Fig. 5. Rainfall values for Bloomington, Indiana, as averaged by various statistical methods.

5. Much climatic computation is based on the cumulating mean, beginning when records were started, and continuing to the year under consideration. Note here that the mean rainfall for the first 25 years of the record is not the same as that for the last 25 years; and that neither is the same as that for the total record.

The progressive average shown in figure 5 is one of several methods used to detect and predict trends. Here it shows a slight erratic upward trend in local rainfall, following a short period of slightly decreased mean precipitation.

The problem of forecasting, as well as that of formulating general working rules, is complicated by the difficulty of applying a general rule to a specific case. For example, the generalization "rainfall variability increases as the total amount decreases" is quite satisfactory when annual totals of rainfall are considered, but fails miserably when monthly totals are concerned. At the four stations considered in figures 1 and 3, in only one case (Salt Lake City) does the month of minimum rainfall also have the maximum variability; and in no case does the maximum monthly rainfall coincide with the month of minimum variablity. Monthly values of rainfall are plotted against monthly variability indices, for the four stations, in the figure 6.

It has been suggested that, whereas a stable average of annual rainfall totals may be attained at most stations in a period of 35 years

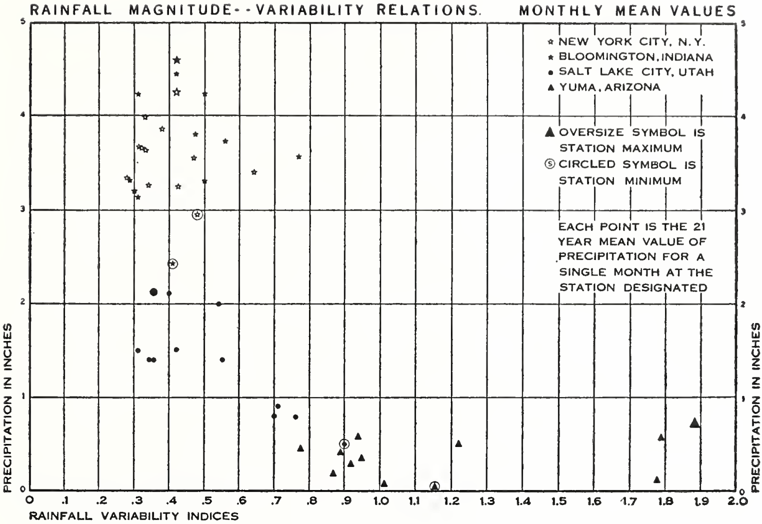


Fig. 6. Rainfall magnitude compared to rainfall variability for the period 1925-1945 for Yuma, Arizona; Salt Lake City, Utah; Bloomington, Indiana; and New York City, N. Y.

or so, the monthly averages will not stabilize until a much longer period has elapsed. Correctness of this suggestion, which is not unreasonable, is hinted at by perusal of the records for London, England. A rigorous check, for a period of about 350 years, for a station where the physical environment is constant, is both very desirable, and completely impossible. There is no such station.

As a result of the multifarious unresolved problems related to cyclical and random climatic fluctuations, possible unidirectional trends, in part "inherited from the Pleistocene ice ages; and the short span of human records and observations; it appears that the more rigorous and valuable statistical methods, such as use of the Pearsonian coefficient of variability, cannot be applied with any hope of correctness to rainfall variability problems at the present time; but that the cruder methods, based on the variability index, are very useful, within their acknowledged limitations, today.

Applications of Rainfall Variability Data

Variability of rainfall is all too commonly considered a problem of interest only in areas of irrigation agriculture. In those areas, rainfall variability is certainly a problem, but nearly every Indiana community is directly concerned with the same problem. Municipal water supplies, for domestic and industrial use, are very greatly affected by cumulating rainfall deficiencies of medium duration (such as 24 months). Before water supplies in many Indiana communities can be regarded as satisfactory, additional construction, to compensate for the effects of both immediate and cumulated water supply shortages, will be necessary.

When the rainfall exceeds the mean value for the period under consideration, the water-disposal facilities are affected. This includes municipal street and sewer departments; flood control works; and erosion control agencies. The problem here becomes quite complex, for the municipal facilities are concerned with getting rid of the water rapidly, whereas the flood control works, as well as the erosion control methods, are designed to retard and stabilize runoff.

Both water storage and water-disposal facilities must be designed to function under a wide variety of conditions, both of excess and scanty water; and to function satisfactorily with a minimum of interference with local water tables. In some instances at least, solution of the problem of flow stabilization has created a new problem of mosquito control.

Both rainfall scarcity and rainfall surplus can be largely compensated for by construction of proper dams, reservoirs, and similar structures, and such structures are costly. Such construction is insurance, and there is always the possibility of overinsurance. If either flood or drought protection costs more than the damage likely to be produced by a flood or drought, there is a possibility that it is undesirable, or "overengineered." In very general terms, water control facilities which permit normal operation when the annual rainfall is within the limits of the annual mean plus or minus twice the annual mean deviation are the maximum that are economically justifiable under present conditions in most areas. Rough probability computations indicate that with such protective measures, normal operation will be prevented by rainfall variations only about once in 20 years.

Conclusions

The foregoing consideration of the problem of rainfall variability indicates that Indiana is located in a region where such variability is not great, and where, in addition, rainfall is adequate for the present economy.

Relatively minor water control works will be able to equalize the annual rainfall distribution sufficiently to permit a slight increase in agricultural production, when construction of such works is economically desirable.

Somewhat more extensive water control structures are already necessary to reduce flood damage, and to provide municipal and industrial water. Many of these works are at present inadequate, and rainfall variability must be considered as they are expanded.

Both overexpansion of water control facilities and overscientific methods of determining rainfall variability must be guarded against, because both are costly errors, leading to overinsurance, and, in most cases, inordinately high tax bills.

FORMULAE

Individual values $= X$

Number of values $= N$

($\Sigma =$"the sum of")

$$\text{Arithmetic mean} = \overline{X} = \frac{\Sigma(X)}{N}$$

$$\text{Individual deviations} = x = |X - \overline{X}| = \left|X - \frac{\Sigma(X)}{N}\right|$$

$$\text{Mean deviation} = MD = \frac{\Sigma|x|}{N} = \frac{\Sigma|X - X|}{N} = \frac{\Sigma\left|X - \frac{\Sigma(X)}{N}\right|}{N}$$

$$\text{Variability index} = \frac{MD}{\overline{X}} = \frac{\Sigma\left|X - \frac{\Sigma(X)}{N}\right|}{\Sigma(X)}$$

$$\text{Standard deviation} = \sigma = \sqrt{\frac{\Sigma\left|X - \frac{\Sigma(X)}{N}\right|^2}{N}}$$

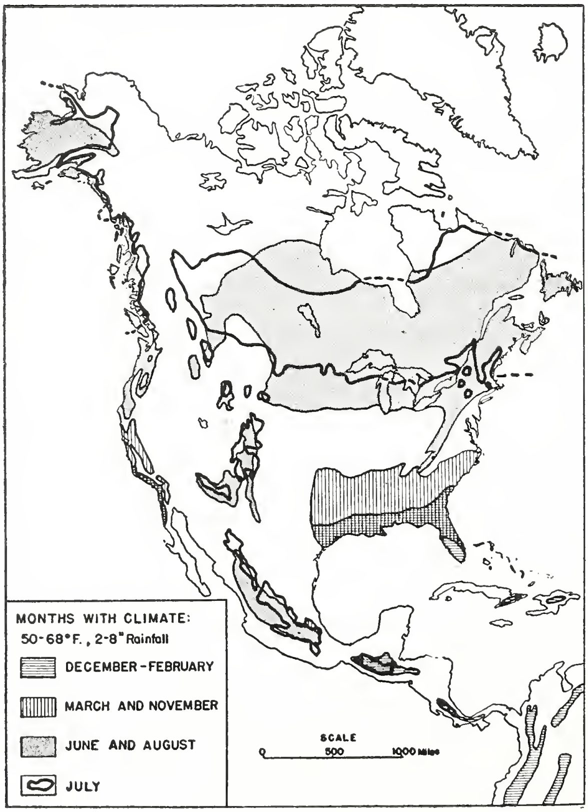
$$\text{Coefficient of variability} = \frac{\sigma}{\overline{X}} = \frac{\sqrt{\frac{\Sigma\left|X - \frac{\Sigma(X)}{N}\right|^2}{N}}}{\frac{\Sigma(X)}{N}}$$

Optimum Indiana Weather Elsewhere

Otis P. Starkey, Indiana University

During World War II our army was called upon to operate under a great variety of climatic conditions and ignorance of overseas climatic conditions often resulted in the assignment of unsuitable equipment to many units. Subsequently the Office of the Quartermaster General established a Climatology Unit which prepared maps showing climatic conditions month by month for each continent. These climatic zone maps have been used by the armed forces and by a few geographers but few business applications have been reported. Here it is suggested that broader civilian use of these maps is feasible and their application to the tourist business is offered as an example.

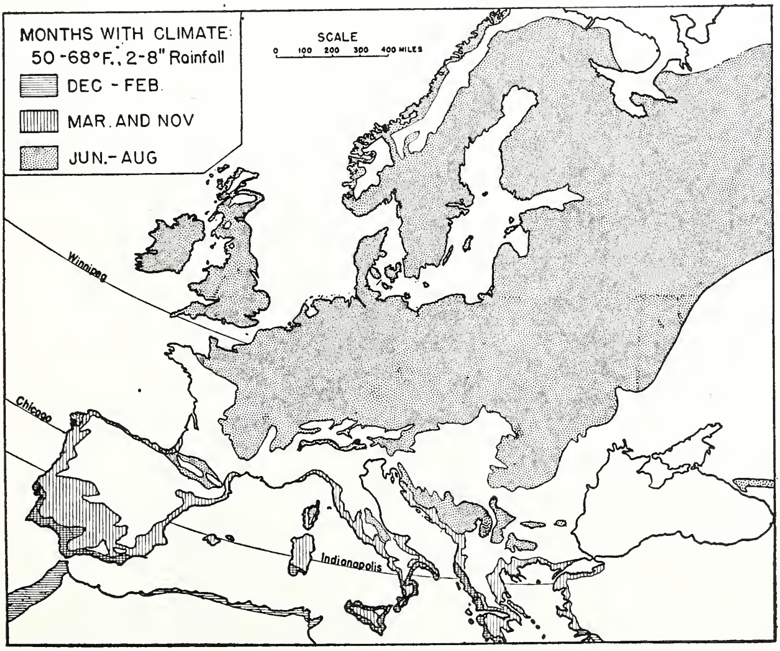
In this hypothetical case let us assume that a Hoosier tourist is anxious to spend a vacation in weather comparable to the best Indiana has to offer. Our tourist, like most of us, prefers the common Indiana



weather of April and May and its autumn counterpart in September and October. At such seasons a medium-weight wool suit, supplemented at most by a topcoat, provides comfortable attire. Statistically such weather occurs with monthly averages between 50° and 68°F. and in Indiana is accompanied by from 2 to 8 inches of rain per month. The climatic zone maps classify such a climate as *mild* and *humid*.

The climatic zone maps make it easy to discover where this, or any other climate, can be experienced each month of the year. The accompanying figures generalize some of this data to show the possibilities open to our hypothetical Hoosier tourist in North America and Europe. Note that these maps do not show where exact duplicates of ideal Hoosier weather may be found: differences in winds, thunderstorms, diurnal fluctuations and the like are disregarded. But the maps do show where clothing and other equipment suitable to Indiana spring and fall weather would be appropriate.

The map for North America (figure 1) offers only a few surprises. Thus the optimum weather occurs in the central American highlands in winter and summer but on the Mexican plateau only in summer. Some of the lands commonly visited by winter tourists fail to meet our tourist's criteria; thus Mexico and much of the American Southwest are too dry and the Caribbean lowlands are too hot. In June and August extensive areas in our country are classified as mild but in July a visit to Canada or a few mountain areas is necessary to avoid the heat and to approximate Indiana's late spring.



The Europe map (figure 2) shows that only narrow areas around the Mediterranean have mild humid weather in winter. Even the presence of these areas is noteworthy when it is observed that the parallel of Indianapolis extends through the center of the western Mediterranean Basin. In summer most of Europe has ideal weather from June to August and this weather is so equable that it is unnecessary to differentiate July from June and August as in North America. The relative freedom of western Europe from extreme heat is explained by its latitudes which are similar to those of Canada.

With the basic climatic zone data, other maps to fit other requirements could easily be constructed. Maps showing the distribution of dry, mild climates would be of value to those suffering from sinus. Maps showing the distribution of warm, dry climates would be of interest to those suffering from colds and rheumatism. By applying this climatic data in such ways, geographic patterns take on practical significance and change from mere academic wisdom to aids in the planning of human activities.

Soil Conservation in Action

G. David Koch, Indiana State Teachers College

One of the most serious problems confronting the nation is that of soil erosion. During the past decade it is heartening to learn that farmers and other individuals are awakening rapidly to the growing menace of soil losses. In most parts of our country steps are being taken to counteract the erosion evil. Farmers, with the aid of local, state, and federal agencies are putting into operation means by which soil conservation will succeed.

The first step in establishing any soil conservation program is that of interesting the farmer in the plan and proving to him the economic validity of soil conservation practices. This first hurdle is best crossed by the actual demonstration of soil conservation procedures and the results obtained by careful farm planning.

Among the problems that need most to be demonstrated are those of water, soil and crop management.

This paper is a report of a soil saving demonstration which was held on a Vigo County, Indiana farm last September.* The farm is 160 acres in size and the physical characteristics are typical of upland farms in that part of Vigo County. The topography is rolling with slopes ranging from two to fifteen per cent. However, at least three-fourths of the farm has a slope below five per cent. The soil is silt loam, with a light grey topsoil, fine textured and medium acid in reaction. As shown in table 1, the cultivated soil has an average p.H. of 6.5, which is quite near the normal p.H. of 7. The present p.H. in the tilled fields is the result of applications of lime during the past five years.

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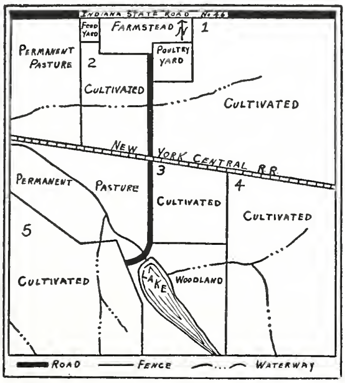
* The farm is owned by Dr. H. M. Bratt, of Terre Haute, and is the first farm east of Riley, Indiana on the south side of State Road No. 46.

The pasture land, where no lime has been applied, has a much greater acidity (table 1).

TABLE I. Chemical Condition of the Soil in 1948 by Fields.

Field	p.H.	Phosphate	Potash
1	6.4	Low	Medium
2	6.5	Low	Medium
3	6.4	Medium	Very high
4	6.6	Low	High
5	6.6	Low	High
Pasture	5.8 or below	Very low	Low

Of the total area of the farm, 104 acres are under planned cultivation, 27 acres are in permanent pasture, 10 acres are in woodland and the remaining 19 acres are occupied by farm buildings, feed lots, poultry yards, a railroad, and roads. The arrangement of the farm, as it was on demonstration day, is clearly illustrated in figure I.



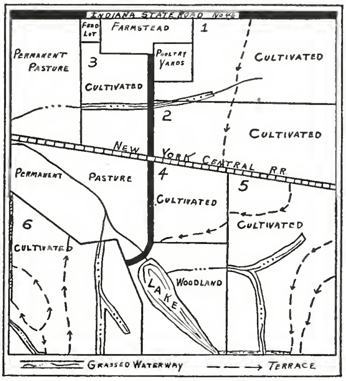


Fig. 1. The arrangement of the farm prior to Demonstration Day.

Fig. 2. The farm map with terraces located, as constructed and the location of proposed grassed waterways.

The farm has been under a planned crop and fertilizer program since 1943. During this five-year period all boundary and all cross fences have been made hog-tight. The barn has been remodeled and a concrete feeding floor constructed. The farmstead is also equipped with a running water system. Further improvements are under consideration. During the past five years, since the farm has been under the present ownership, the raising of livestock has been the primary interest. Plans call for more emphasis on livestock during the next five year period.

Losses, due to water erosion, are evident at numerous points on the farm. In field number four, figure I, a gully a foot deep and one to two feet wide extends up the drainage way from the wood tract. It has been cut back into the field for at least 100 yards. Thin topsoil is also evident on the steep slopes in the southeast part of field four.

In field five numerous evidences of erosion are present. In the southwest corner steep slopes have aided the development of several short gullies. These gullies have impeded the use of farm machinery. On the east side of the same field a drainage way exists. Below the junction of the two drains, a wide flat bottomed runway has been eroded. The slopes of this drainage way are steep, being 10-15%. Sheet erosion is excessive here. On the day of the demonstration, this erosion was clearly seen. The light yellow soil of the steep slopes contrasted sharply with the darker soil on the bottom of the runway and adjacent uplands.

The drainage line crossing field 2 is also actively eroding a small gulley, which if left uncontrolled would soon eat its way back into field one. The wooded area is well under control because of the permanent stand of trees. The lake is artificial.

To develop a long range farm plan, the first step is that of making an inventory of the farm. This includes an anlysis of the soil, measure-

Table II. Crop and Fertilizer History by Fields.

FIELD	1943	1944	1945	1946	1947	1948
No. 1 Crop Yield Fertilizer applied	oats 50 bu.	beans 12 bu. 200 lb. 2-12-12*	wheat 20 bu. 300 lb. 2-12-12	clover 1 ton	corn 80 bu. 1000 lb. phosphate	corn 400 lb. 3-12-12
No. 2	rye 10 bu.	clover pasture	clover pasture	corn 70 bu. 500 lb. 3-12-12	beans 26 bu. 100 lb. phosphate	wheat 30 bu.
No. 3	rye	rye 10 bu.	clover 1½ ton	corn 60 bu. 200 lb. 3-12-12	beans 26 bu. 1000 lb. phosphate	wheat 30 bu. 400 lb. 3-12-12
No. 4	corn 20 bu. 200 lb. 3-12-12	pasture	beans 12 bu.	wheat 12 bu. 250 lb. 3-12-12	clover 1½ tons	clover pasture 100 lb. phosphate
No. 5	beans 10 bu.	corn 20 bu. 400 lb. 3-12-12	beans 12 bu.	oats 15 bu.	sweet clo. pasture	sweet clo. pasture

* Proportionate parts of nitrate, phosphate and potash respectively. Each field has received 6 tons of lime during the period.

ment of steepness of slopes, extent to which erosion has taken place and the available water supply. Once the inventory has been made and carefully analyzed the conservationist is then in a position to offer plans for future farming practices. Such practices include planned crop rotations, gully control, sheet erosion control; exclude over-grazing and over-cropping. Among erosion control measures are grassed waterways, terraces, and contoured cultivation.

Crop rotation and fertilization have been followed during the past five years on the farm herewith discussed. The results are set forth clearly in table II. The table includes the rotation plan, yields, and fertilizer applied for each field on the farm. A study of the yields shows a steady increase in production, especially during the past two years.

However, continued loss of water and subsequent soil erosion, during the five year plan, were evidence that crop rotation and fertilization were insufficient for complete control. Consequently a new five year plan has been established. In addition, the building of terraces and grassed waterways are included in the new plan.

An examination of figure II and table III shows the proposed arrangement of the farm and the proposed crop rotation. It may be noted that field 1 has been divided into two parts.

TABLE III. Proposed Crop Rotation by Field 1949-1954 inclusive.

FIELD	1949	1950	1951	1952	1953	1954
No. 1	oats & alfalfa	alfalfa	corn	beans	wheat	alfalfa
No. 2	beans	wheat	alfalfa	alfalfa	corn	beans
No. 3-4	clover	corn	beans	wheat	alfalfa	alfalfa
No. 5	corn	beans	wheat	alfalfa	alfalfa	corn
No. 6	wheat	alfalfa	alfalfa	corn	beans	wheat

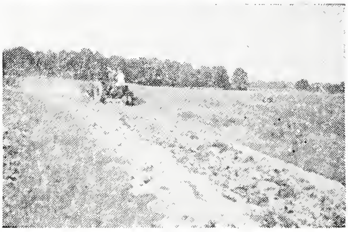
From table III one learns that fields 3 and 4 will be utilized for the same crop. The permanent pasture will remain as such, as will the woodland plot. All of the drainageways that cross cultivated fields will be grassed. Another sodded waterway is to be added along the south line of field 5. It will be seen that each of these grassed waterways drain into either a permanent pasture or the woodland plot, a logical and proven practice. Each of the sodded drains will check gullies now present or potential. None of the sodded drains had been constructed on demonstration day.

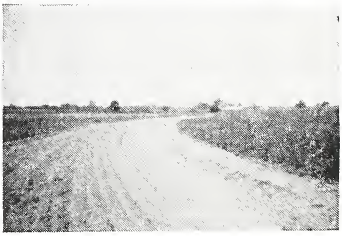
All of the terraces shown in fields 5 and 6 were constructed on demonstration day. Preliminary surveys and lines for these terraces had been made and drawn prior to the demonstration. The terrace across fields 1 and 2 has been in operation for a year. Since field 3 will be in red clover until 1950, table III, the construction of the terrace across it will be postponed until that year. Each terrace empties into a grassed waterway or land permanently out of cultivation. The railroad company granted permission to drain the terrace across fields 1 and 2 into the right of way.

From the proposed crop rotation plan, table III, it is noted that alfalfa, a new crop to the farm, will play an important part in the rotation system. Alfalfa and sweet clover will be depended upon to aid materially in replenishing nitrogen, a chemical used heavily by corn. Since livestock will be the major interest, alfalfa will also furnish needed forage for winter feed.

Alfalfa is recommended over red clover on this farm chiefly because it is a deep rooted legume. Although the soil is low in phosphate, Table I, it is sweet enough to grow alfalfa successfully. Addition of phosphate and potash through commercial fertilizers will aid in securing and maintaining a good stand of alfalfa. Since in most cases wheat precedes alfalfa in the rotation, Table III, the grain will be the "nurse" crop for the legume.

All cultivated crops are heavy users of soil fertility. A seventy bushel corn crop removes about 70 pounds of nitrogen, 28 pounds of





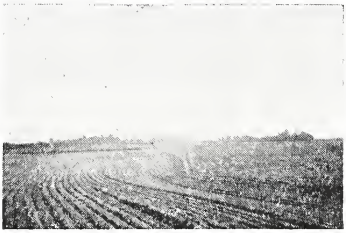


Fig. 3. View in farmyard of Bratt farm just before field trips began.
Fig. 4. Plowing in a terrace. Special auger moleboard plow in use.
Fig. 5. Plowing in a terrace. Common moleboard plow in use.
Fig. 6. A completed terrace in field 5.
Fig. 7. A completed terrace in field 6.

phosphate, and 32 pounds of potash per acre. A twenty-five bushel soy bean yield, harvested for grain, needs 88 pounds of nitrogen, 20 pounds of phosphate and 38 pounds of potash. The bean plant of course secures much of its nitrogen from the air.

The above data means that, in order to secure satisfactory yields and at the same time maintain or improve soil fertility it will be necessary to apply some commercial fertilizer. However, whenever possible, green manure and barnyard manure should be utilized to the best advantage. That is, after all, Nature's way.

On demonstration day flat bed trailers pulled by tractors, furnished means of transportation over the farm for the visitors, figure III. During the morning, the visitors were shown the plows, in operation, building the terraces, figures IV and V.

After lunch, served by a local women's organization, those present enjoyed a chalk talk by an outstanding proponent of soil conservation. After the speech, transportation was again furnished those who desired to observe the completed terraces, figures VI and VII.

Although a farm under complete soil erosion control was not demonstrated, the project was stimulating. The results of a planned five year rotation were shown, terraces to control runoff and sheet erosion were constructed and the projected grassed waterways to control gullying were located. The fact that over seventy-five percent of those present returned to the fields in the afternoon for a second look revealed their interest. It is believed that the demonstration will lead the way toward the formation of a Soil Conservation District in Vigo and adjacent counties.

A Study of the Cucumber Industry at Terre Haute, Indiana

Robert Rudd, Indiana State Teachers College

The largest greenhouse in the world with one central heating plant is located at Terre Haute, Indiana. Davis Gardens, as it is known to the local populace, started from two one-acre greenhouses in 1914 and today has 35 acres under glass with an actual growing area of 1,020,000 square feet. The difference between this figure and the former one is due largely to the fact the greenhouse proprietor counts the sides, ends, and roofs of the buildings in totalling acreage under glass. Of the total growing area, 33 acres are used for growing cucumbers, while the remaining two acres are used for the production of tomatoes. The latter crop is grown on an experimental-commercial basis. Experiments are being carried on with various types of cultures, hydroponics mainly. At the same time, production is maintained at a commercial rate. During the height of the growing season approximately 2500 pounds are picked daily. Cucumbers are grown entirely on a commercial scale. From the 15th of December until about August 10th an average of 2000 dozen fruits are picked daily. This industry has grown to such proportions that it is a major source of hothouse cucumbers for the great vegetable distributing warehouses in Boston, Cleveland, Detroit, Chicago, and other main distribution points in eastern United States.

Location

A considerable amount of geography was employed in the original selection of the site for this unique but definitely successful enterprise. Many factors must be considered in locating a greenhouse. First of all, the latitude should be such that the greenhouse can produce for a considerable period of time before and after field production is possible in that locality. Location should be far enough north so that the normal growing season is relatively restricted; yet care must be taken not to locate so far north that excessive costs on items such as fuel will materialize.

An extremely important factor is that of markets. Not only should a good market be available in the immediate vicinity, but access to other markets through suitable transportation facilities is important. Orginally most of the shipping of the product was done by rail, consequently access to several large railroad systems was necessary. Four large railroads have routes through Terre Haute making it a good location for that reason. The New York Central, Pennsylvania, Chicago and Eastern Illinois, and Chicago, Milwaukee, and St. Paul railroads have a combined coverage of considerable market area. Emphasis later shifted to shipping by truck, and today the majority of Davis Gardens produce is carried by a truck fleet. The "crossroads of the nation,"

U. S. 40 and U. S. 41 pass through Terre Haute and add to its desirability as a shipping center.

In choosing a greenhouse location, a nearby source of suitable fuel is essential. At the time Davis Gardens was established the bituminous coal of the Indiana coal fields seemed an excellent source of supply. When the average tonnage used per year is realized, the desirability of a very close source is apparent. An average of 20,000 tons are burned annually. Freight costs from the Mount Pleasant Mine four miles from Davis Gardens and from the Blackhawk Mine ten miles away are not nearly the factor they would have been in a less suitable location. A major fuel-saving item is sunlight. The importance of sunlight may be more thoroughly realized when the fact is considered that on a sunny day, even though the air outside has a temperature near 0°F., the heat may be turned off entirely for the several hours that the sun's rays are most direct. Water vapour in the enclosed air of the greenhouse condense on the glass readily; and, after running into cracks around the glass plates, it freezes on contact with the air and effectively seals the leaks. Other conditions, a calm day for example, are necessary for such fuel saving opportunities; but sunlight is the major factor. In considering this point Weather Bureau records over a considerable number of years were consulted for the percent of possible sunshine during the so-called "dark months." Figures from the U. S. Weather Bureau Bulletin list 42% of possible sunshine for December, 45% for January, 48% for February, and 53% for March in Terre Haute. Mean normal temperatures are important also, of course, in fuel consideration. From the same publication the figure for Terre Haute in December is 32.5°F., January is 28.7°, February is 31.3°, and March is 40.6°. No one particular item of location is sufficient; many must be considered before a decision is made. Certainly in this instance many major items combined to make the present location desirable. Other factors (source of fertilizers, labor supply, type of

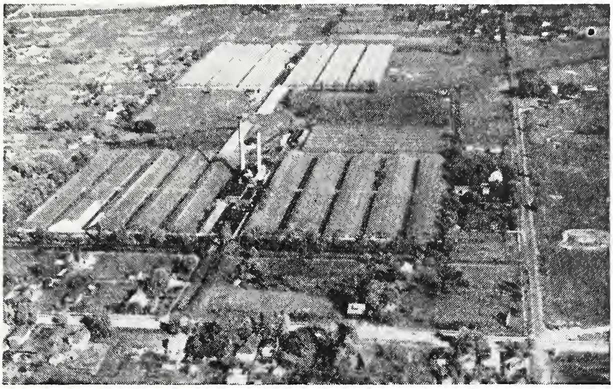


Fig. 1. Aerial view of Davis Gardens.

labor) will be referred to that perhaps are not major ones; still their combined effect is one of aiding rather than deterring.

Heating

Mention was made earlier that Davis is the largest greenhouse in the world with one central heating plant. Other greenhouses have larger area under glass but heating is accomplished through several small heating plants. At Davis Gardens the heating plant consists of four boilers, two with a 500 horsepower rating each and two with a 600 horsepower rating. When the plant was built, stoker size coal was considerably cheaper than ordinary lump. Since the advent of the home stoker relative prices of stoker coal and lump coal have changed; and it may soon be cheaper for Davis to install a crusher so that lump coal, some of which is cheaper, can be used. Fueling is accomplished by Babcock and Wilcox chain grate stokers. A low pressure steam heat system is in use and steam at 125 pounds per square inch is conveyed from the heating plant to distribution points from whence it is further distributed into the various greenhouses. This particular pressure is used since it provides approximately as dry a steam as is feasible. The longest push is one of 1000 feet to one of the distributing points in a 12 inch pipe, or header. Inside the greenhouse the steam enters in low pressure headers, and is conveyed into a series of coils, some along the sides, others near the roof and in the center of the building. Temperatures in the greenhouse are regulated very carefully to secure optimum growing conditions. A night temperature of 66°F. is maintained which varies from the day temperature. Even day temperatures vary according to whether the day is cloudy or sunny. It is of interest to note that on sunny days a temperature of 85°F. is maintained. On cloudy days the temperature is held at 75°F. since less photosynthesis occurs, and higher temperatures cause the vines to stretch. The greatest foe of even temperature maintenance is a cold, windy day. Rapid movement of cold air about the greenhouse buildings constantly robs the area of heat. In a 24 hour period on such a day 250 tons of coal may be consumed. In contrast 100 tons are burned on a calm day with the same outdoor temperature.

Cucumber Culture

Producing cucumbers at a rate of 2000 dozen a day is something that requires considerable planning and careful methods. From the seed to the final product, established practices are maintained in the care and growing of the cucumber plant. Many of the procedures have originated in the experimental plots at Davis Gardens. The cucumber seed is sown about October 15th in a specially prepared seed bed made of compost soil and sand. This growing medium is not as rich as the soil into which the seedlings will be later transplanted. Sowings are staggered, about 20,000 a day being an average sowing, so that too many of the seedlings will not require transference into the pots at the same time. On the third day following the sowing, most of the first group of plants have attained the inch and one-half height required for potting. The plants are maintained in a special propagating house from the time of sowing until two weeks after potting. The seedlings are then planted in the area where they are to bear fruit. Use of a central propagating house for sowing and care of the young seedlings eliminates the problem of very careful temperature regulation throughout the entire greenhouse area as well as cutting fuel costs. During the two weeks potting period careful check is kept on the seedlings, and those which fail to show satisfactory progress are eliminated. This measure insures a majority of top quality plants and makes unnecesary constant replacement of plants that fail at various intervals after final planting. The growing soil used is a sandy loam with fairly high humus content. During the growing season of a crop, approximately 200 tons of manure are used per acre. When total acreage is considered it is realized that location not too far from a source of fertilizer is desirable. The Chicago stockyards, an ample source, are not too far from Terre Haute and the rail connections are good. Some 200 carloads are used during a normal growing season by Davis Gardens.

Of interest too is the preparation of the growing area. Many problems that later might arise are eliminated by careful methods of sanitation and sterilization. About August 10th preparation for the fall crop begins. Sulfur is burned in the growing areas to dry up the vines of the previous crop. All vegetation is removed from the beds and burned in an outside area. The soil in the greenhouse is subjected to roto-tilling. A foot beneath the surface of the soil, a four inch drain tile has been laid in all the growing beds. After covering the soil with canvas, live steam is blown through the tile until the temperature of the soil is brought to 200°F. This method is believed to take care of any plant diseases, plant or insect life present in the soil. After being subjected to the high temperature for some time, the soil is found to have an extra-ordinarily high concentration of salts near the surface. Overhead sprays are employed to re-distribute the mineral through the soil more thoroughly. When this has been accomplished, manure is applied to the growing area and sprayed repeatedly with D.D.T. to eliminate the fly menace. In this prepared area the two week old seedlings are planted about November 1st. Various methods of cultivation, heading and securing a maximum number of laterals in a given length of stem, occupy the worker's time from planting till picking commences. Application of fertilizers is held to a fixed schedule during the period of cultivation and while the plant is bearing fruit. In addition to manure considerable quantities of commercial fertilizer are used. Commercial fertilizers used include muriate of potash, acid super-phosphate, and sulfate of ammonia. Minor elements such as copper, boron, zinc, and manganese are added to the soil at two or three year intervals. The plants are given a start toward climbing wire trellises which extend up the sides of the greenhouse and then horizontally toward the center where they join other structures originating in beds nearer the middle of the building. Since the cucumber plant is a vine, little difficulty is experienced

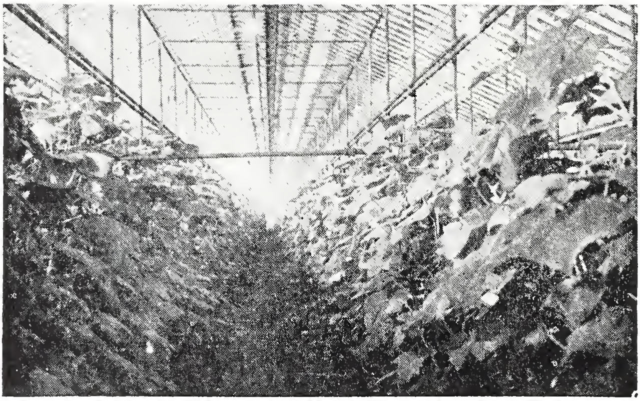


Fig. 2. Inside view of the Cucumber Greenhouse.

in keeping the plant growing upward. There are several reasons for this procedure: it causes more of the plant to be exposed to sunlight; it keeps the cucumbers off the ground where they become discolored or are subject to softening; and it provides a maximum growing area for a given amount of space. The first cucumbers are ready for picking about December 15th and within a month the average figure of 2000 dozen per day is usually reached.

Tomato Culture

The tomato cultures at Davis Gardens are of interest for several reasons. As was mentioned earlier, tomatoes are grown partly on an experimental basis. Work with hydroponics is carried on with the idea in mind of using it on a large scale when minor problems are eliminated. Two types of culture are used: the sub-irrigation type, or gravel culture, and the constant flow type, or water culture. The sub-irrigation type at Davis Gardens employs a water-tight growing bed six inches deep and three feet wide filled with some aggregate such as gravel or haydite, a cinder-like material. A half tile forms an inverted trough in the center of the bed under the aggregate. The bed is so constructed so as to have one end slightly lower to facilitate drainage. Water, containing plant food, is pumped through the tile several times daily, the number dependent upon the type of aggregate and the stage of plant growth. The object is to pump water into the bed until it reaches the upper level of the gravel and then allow it to drain leaving some of the nutrients in the aggregate where it is available to the plant. In the case of water culture, no aggregate is employed. The plants are supported by structures above the water beds and the plant roots are merely suspended in the solution. Care must be taken to keep the light from reaching the roots, and canvas or a similar covering may be suspended just above the water level as a preventative to the growth of algae on the roots. This method differs from the sub-irrigation method also in that the water is

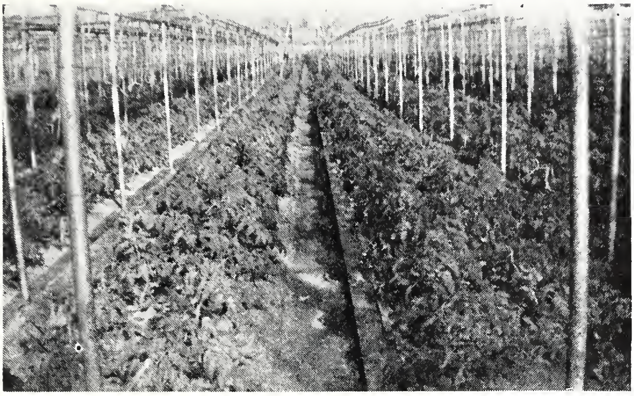


Fig. 3 Hydroponics beds at Davis Gardens. Gravel culture at left and water culture at right.

constantly flowing rather than being changed at intervals during a given time period. The same nutrient solution is used over and over with periodic analyses being made to see that a sufficiently rich solution is maintained. The water culture employs the same nutrient solution as the gravel culture at Davis Gardens. The food itself is composed of all the major elements including calcium, magnesium, nitrates, phosphates, and potash with minor amounts of such elements as iron, copper, and boron. Formulas for the solution used at Davis Gardens were obtained from Purdue University.

Planting and potting methods used are similar to those used in starting the cucumber plant. One of the problems of tomato raising is the setting of the first hand, or causing the first cluster of tomatoes to form. To facilitate the early setting of the hand, the first two clusters of blossoms of each plant are sprayed with a hormone, indole-butyric emulsion. The rest of the hands are set by the workers daily tapping the plant which shakes the pollen loose and facilitates fertilization. Since both the stamen and pistil are present in each bloom of the tomato plant, fertilization is easily thus accomplished. The tomato plant, however, is not the climbing type vine that the cucumber is; consequently, the growing ends of the plant must be repeatedly wrapped around vertical cords which are attached to overhead structures. Conservation of space and presentation of more fruit to sunlight are basic reasons for this type of growing structure. Two crops of tomatoes a year are produced. The first yield is secured from April 1st to July 15th and the second crop from September 1st to December 1st.

In contrasting the products of the two hydroponics beds and those of a soil culture similar to that used in growing cucumbers, several facts come to the fore. The sub-irrigation method, as used at Davis Gardens, requires a shorter growing season, produces a higher yield, and is less costly than either the soil culture or the constant flow culture. Irrigation in the case of the constant flow culture requires 2½ times the quantity of solution since it is a constant flow proposition, and the pumps are operating 24 hours a day. This is a major item of cost in the latter type culture. The quality of tomatoes produced under each culture was so nearly the same that this factor was discounted.

Problems

Problems encountered in greenhouse work are many and varied but those of chief concern are plant disease and insects. The major factors which have been successful in combatting these two hazards are sanitation and sterilization. Preventative measures include fumigation before and after each crop with sulfur and azo-benzene. During sowing and potting periods all materials, insofar as possible, are sterilized and a high degree of cleanliness is required of the workers. Elimination of weeds in grounds between and surrounding greenhouses has been found to aid considerably in pest control. The red spider, a type of mite, is the insect that causes the most trouble at Davis Gardens. Preventative methods have been mentioned. Whenever a leaf is found that has been attacked by the insect, it is pinched off, taken outside, and burned. The area from whence the leaf came is then subjected to spot spraying with hexa-ethyl-tetra-phosphate. If a cluster of spots appear, the area is marked off and thus transference to other plants is held to a minimum. Azo-benzene is applied to the heating pipes in the area and thus is dispersed to the plants. Other insects that constitute problems are the aphid, thrip, and the cucumber beetle. The latter becomes a real menace usually late in the spring. A juice sucking insect, the beetle impregnates the plant with a type of bacterial wilt at the same time it is sucking the plant juices. D.D.T. has been found to be effective against this insect and is applied with the aid of aerosol D.D.T. bombs. Not all insects are effectively controlled with D.D.T. however. To combat the aphid and thrip, Davis Gardens use nicotine pressure cans. These instruments consist of a can with a restricted opening and containing nicotine mixed in a powder. When ignited the powder creates tremendous volumes of dense smoke clouds which contain the nicotine.

In controlling plant disease, prevention by sanitation and sterilization are foremost. Whenever a plant becomes diseased, it is removed and destroyed. The area must be isolated since it is very easy to spread some types of plant disease. Powdery mildew is probably the greatest enemy as to cucumber plant diseases at Davis Gardens. It is a mold that appears on the foliage and stems, and is caused mainly by high humidity and stagnant warm air. Sulfur applied to the steam pipes is effective in dehydrating the air and killing this trouble maker. It has been found that a good principle to follow is: keeping down insects keeps down plant disease too.

Distribution

Produce from Davis at Terre Haute is distributed throughout a market area from the Mississippi River to the east coast, and the services of an entire truck fleet are required to keep warehouses from

Canada to the southland supplied. A second plant at Davenport, Iowa in conjunction with one at Aurora, Illinois ships to the western areas. Timing involved in these shipping operations is important for several reasons. The product is a perishable one and delays are usually costly. Then too, as is true of many such products, changes in prices are often sudden; and, though the change per cucumber may be small, the total change on a truckload is considerable. The value of one truckload often exceeds $10,000. Shipments in the early part of the season are usually to the New York area and Boston. A short while later Chicago, Cleveland, Detroit, Syracuse and others are added. Davis cucumbers have been shipped to Europe on occasion, but the producer's themselves did not do the shipping. Distribution from the large eastern wholesale houses was responsible for overseas shipment. It is believed, however, by Davis Gardens that their product entered the African continent under rather novel circumstances. A Davis official, in chance conversation with a fellow traveler, mentioned the company by which he was employed. The other traveler, an Army officer, asked if it was the same company that was concerned with cucumber raising. It developed that the officer had been in charge of one of the first supply waves to come ashore during the North African Campaign, and he had remembered the large volume of Davis cucumbers that were present in those supplies since they seemed an odd item of war material. It is possible that their purpose was to provide an item of freshness to what perhaps was otherwise rather drab food.

On the occasion of Will Rogers' visit to Terre Haute, the great humanitarian was conducted through Davis Gardens as a part of his seeing the interest spots of the city. Upon conclusion of the tour he is said to have remarked, "Well, I had to come all the way to Terre Haute, Indiana to find out there were people that grew cucumbers on purpose."

Notes on the Size, Distribution, and Growth of Indiana Cities

THOMAS FRANK BARTON, Indiana University

The size of the cities in this article will be based on the 1940 census. The writer plans to prepare a paper comparing the size of Indiana cities of 1940 with that of 1950 as soon as the statistics become available.

Size and Distribution

Our state's cities are characteristically small. There are 100 political units with populations over 2,500. Of these, nearly one-third or 32 have less than five thousand; and 33 more have a population of five to ten thousand. By combining these two groups, we have sixty-five cities or sixty-five per cent of them with a population of less than ten thousand. There are 15 cities that range from ten to twenty thousand, and 12 that have from twenty to fifty thousand inhabitants. In 1940, only 4 out of the 100 had a population of over one hundred thousand, namely, Indianapolis, Fort Wayne, Gary, and South Bend. Undoubtedly, the 1950 census will show Evansville in this group.

In the United States, it is common practice to classify cities into *small* (2,500-25,000), *medium-size* (25,000-100,000), and *large* (over 100,000). Applying this classification to Indiana cities, we have 82 small, 14 medium-sized, and only 4 large cities.

Indiana does not have a metropolis. Indianapolis, our largest city, in 1940 had a population of less than 400,000. Yet, adjacent to this state and easily accessible to our people are three cities with a million or more inhabitants. Within a radius of 150 miles of Indiana is St. Louis to the west; Chicago to the northwest; and Detroit to the northeast. Two additional large cities are located just outside the boundaries of the state. To the southeast is Cincinnati with a population of nearly a million and to the south is the large city of Louisville. Chicago, Cincinnati, and Louisville are so close that the metropolitan districts of which they are the centers, actually occupy parts of our state.

In this post-war period, the small size of our cities may be an advantage. Industry is moving from larger to smaller cities. Big enterprises are beginning to scatter their future plants rather than concentrating them in one place. The National Industrial Conference Board reported in May, 1948, that "It had queried 148 large manufacturing companies and learned that of the plants they built or acquired before 1940 nearly half were in cities of 100,000 and more. But in the period 1940-1947, only one-third of the new plants were in cities that large. Cities of from 10,000 to 100,000 were most popular. There was a large increase, too, in the number of new plants placed in cities of 10,000 or fewer." Let us keep in mind that all but four of our cities have a population of less than 100,000.

Pattern of Indiana Cities

The cities over the state are so distributed that they form several major and minor patterns. Looking at a map, one can see at first glance that they are grouped along an axis extending in a northeast-southwest direction across the state. A line drawn from Evansville on the southeast through Indianapolis to Fort Wayne on the northeast marks the approximate core of this axis. Adjacent to this line and on either side of it are grouped most of the large and small cities of Indiana.

This northeast-southwest axial pattern is due to a combination of physical and cultural factors. Some of these factors are: 1. the orientation of Indiana rivers from northeast to southwest, especially the Wabash and the west fork of the White River; 2. the early significance of water transportation, especially on the Maumee-Wabash rivers and canal; 3. the extension of the National Road from Richmond to Indianapolis and Terre Haute; 4. the Kankakee swamps in northwestern Indiana between the Wabash drainage area and Lake Michigan; and 5. the poorer agricultural potentialities in southeastern Indiana.

The one big exception to this axis pattern is a group of cities in the extreme northern part of the state. Here a second and smaller axis consists of cities grouped along a line drawn from South Chicago and Gary to South Bend and Elkhart.

Another major city pattern is the semi-circular zone of cities found grouped to the north half-way around Indianapolis. This semi-circular zone starts with Terre Haute on the west and swings north through Lafayette to Logansport and Peru. Then it turns southeastward through Marion, Muncie, Anderson, and New Castle, and ends in Richmond and Connersville. In this zone and within a seventy mile radius of Indianapolis are 15 of the 27 cities having a population of between ten and fifty thousand. Also within 70 miles of Indianapolis and to the south are three additional cities of ten to fifty thousand that form a nucleus which may someday help extend the semi-circular zone and make it a circular one. These three cities are Bloomington, Columbus, and Bedford.

The cities in southern Indiana are generally smaller than those in the central and northern parts. South of a line drawn from Terre Haute to Indianapolis and Richmond is more than a third of the state. Of the 34 cities in this southern area, 25 have less than ten thousand inhabitants. Evansville is the only large city. In this area we also have two of our 12 cities ranging from twenty to fifty thousand in size, and six of our 15 cities from ten to twenty-thousand.

There is a large wedge-shaped area in Indiana that does not have one city with a population of over ten thousand. This area is between the Wabash valley and the Chicago metropolitan district and is occupied in part by the recently drained swamplands of the Kankakee River.

A distinctive minor urban pattern is a line of cities strung along the Wabash-Maumee Rivers. Today water transportation along this historic route is insignificant, but these cities after their early start continued to grow because of other geographic factors.

In fact, most Indiana cities of ten thousand or more started as pioneer settlements on waterways and state and national highways. Later they became focal points for railroads, electric interurban lines, and hard surfaced roads.

Growth

From the standpoint of an opportunity to grow, our cities exemplify that early settlements that provided governmental services had the advantage over those that did not. Sixty-three of our 100 cities are county seats. Of the 15 cities with populations of ten-twenty thousand, only two were not county seats, namely, Elwood and Whiting. And only three out of the 12 cities with population of twenty-fifty thousand are not county seats, namely Elkhart, Michigan City, and Mishawaka.

Although the political function was and still is an important factor in the development of our small cities, the presence of urban facilities is an increasingly important factor today. Young people are more critical of their environment and perhaps better able to evaluate it. Influenced by movies, newspapers, radio and the rapidity and ease of travel, our people are observing, comparing, and evaluating various communities. Most people want homes in cities that have paved streets, water and sewage facilities, larger schools, parks, and a variety of professional services. The county seat is often able to measure up to these demands more so than other settlements.

Our urban centers also illustrate the importance of an early start. With few exceptions, the largest cities in 1900 were still the largest in 1920 and 1940.

Since 1900 and especially since 1920, manufacturing rather than retailing, wholesaling, or mining greatly influenced the growth of urban areas. Although mining and quarrying contributed materially to the growth of many cities, few today owe their present size primarily to these industries.

After 1910, the largest urban development took place in strategic northwestern Indiana. This area is astride the important lowland corridor of transit from the portal city of New York to the focal city of Chicago. In the future there will be a tendency for cities here to increase in size and number until they nearly coalesce, forming a continuous urban area from South Chicago to South Bend. The prospects of steady growth for our cities are good.

Some Geographical Factors Affecting the Industrial Expansion of Columbus, Indiana

James Lee Guernsey, Indiana State Teachers College

Location

Columbus is located at 39° 13′ north latitude and 85° 56′ west longitude. It is about forty miles south of Indianapolis, seventy miles north of Louisville, seventy-five miles northwest of Cincinnati and two hundred forty miles east of St. Louis.

Columbus has numerous advantages of its general location. (1) It is located near the nation's center of population. (2) It is located in

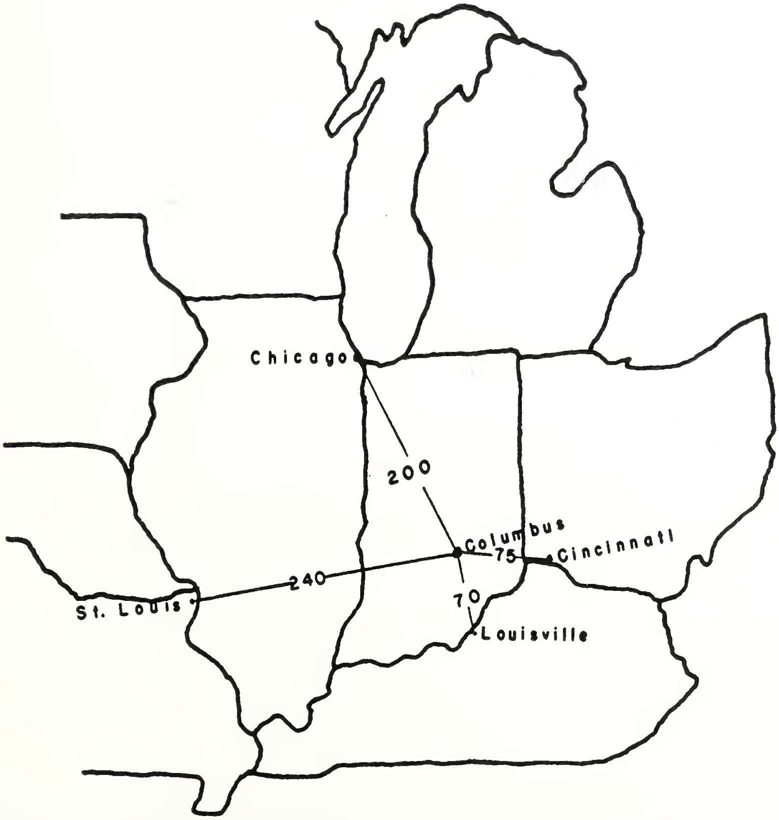


Fig. 1. Columbus—its location with respect to other midwestern cities.

Industrialization

the more progressive eastern half of the United States. (3) The city is located in one of the best corn and wheat belts of the world. (4) It is close to all the major markets of the Middle West. (5) The climatic conditions are favorable for agricultural crops, human energy, and general progressiveness of the people.

Columbus has numerous specific locational advantages for industrial concerns. (1) Proximity to Indianapolis is an advantage as it furnishes a market for various finished products. Indianapolis also supplies wholesale goods to the Columbus area at a relatively low cost. (2) Columbus is favorably located in regard to railroad and highway transportation facilities. (3) Geologically, Columbus is located on the Scottsburg Lowland. The lowland is an erosional and glaciated plain with little local relief which facilitates mechanized agricultural activities and communications. (4) It is situated on a fertile outwash plane formed by the overflowing of Flatrock and Driftwood rivers. This outwash plain is one of the most fertile areas in Indiana. (5) Its location along the East Fork of White River furnished an early means of transportation and has been a source of the city's water supply for many years.

Columbus had 87 industrial concerns in 1947. These industries are well diversified and include metal industries, furniture factories, canneries, plating companies, tanneries, meat packers, and clothing manufacturers. A few of the many various products are auto parts, building supplies, construction tools, electric fans, flour, paper, toilet articles, radios, and Diesel motors.

In 1947 there were 7,768 persons employed in industries. This is about 45 percent of the estimated population of Columbus and about 23 percent of the total population of Bartholomew County. Industrial concerns have increased from 41 in 1940 to 87 in 1947 and the Columbus Chamber of Commerce claims to have more industries per thousand population than any city in Indiana.

The total employment has increased from 3,705 in 1940 to 6,484 in 1943 and to 7,768 in 1947. In 1940, Columbus ranked second in the value of manufactured products per inhabitant in Indiana cities.[1]

The land use map of Columbus (Fig. 2) shows the distribution of the industrial concerns. About one square mile is included in these industrial zones. The industries are scattered since the city has had no city planning commission or city zonation program. The industries are usually found next to the poorer residential districts and the newer industries are usually farther from the general business area although few industries are found outside the city limits.

The payrolls of the industries have increased from $7,969,200 in 1940 to $13,794,892 in 1944 and to $16,794,892 in 1947.

Why have 87 different industries come to Columbus? Why can the Columbus Chamber of Commerce boast of more industrial concerns than any other city in Indiana per 1,000 inhabitants? There are many

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[1] Freeman, Otis. "Major Cities in Indiana." Economic Geography. 1945. p. 120.

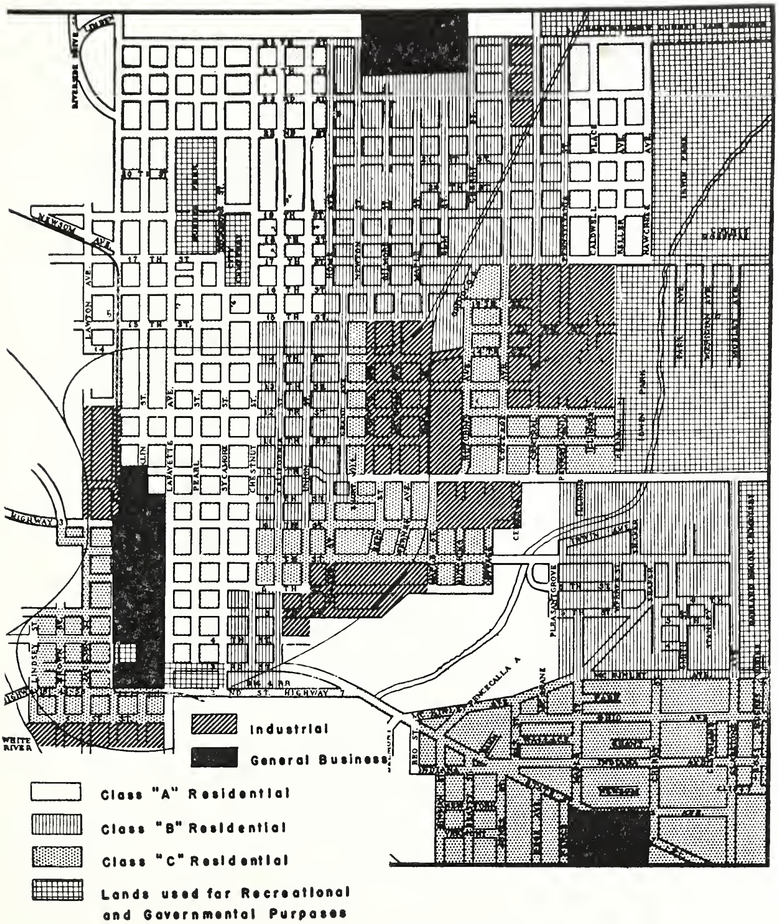

Fig. 2. City land use map of Columbus.

different reasons given by local citizens, but it is generally agreed, that Columbus has the basic conditions for a large industrial development.

Raw Materials

First, Columbus is in a favorable position to obtain raw materials. The canneries, milling companies, paper producers, lumbering mills, dairies, stockyards, chick hatcheries, and tanneries obtain a major portion of their raw materials from the surrounding agricultural area in Bartholomew and adjacent counties. The various metal industries are near the coal deposits in southwestern Indiana, and also fairly near the steel producing areas of Gary, Hammond, Youngstown, and Pittsburgh. Various engineering companies favor the position between Indianapolis, Chicago, St. Louis, Louisville, and Cincinnati from which they secure a major portion of their raw materials to be finished. The nearness to large mid-western packing centers is a favorable factor for the tanneries, and the plastics companies like the location mid-way between Tennessee and Michigan for the securing of their raw materials.[2]

Labor

Since the population of Columbus is only about 15,000 and there are 7,768 people employed in the 87 industrial concerns of Columbus, it is necessary that the industries obtain a considerable amount of their labor from the surrounding area.[3] Although the industrial workers are usually unskilled at the time of employment, most industrial employers agree that the laborers are relatively easily trained and now most industries have a sufficient supply of skilled and semi-skilled workers.

Camp Atterbury has played an important part in the recent population growth and labor supply of Columbus. Camp Atterbury is located about eight miles northwest of Columbus and occupies about 42,000 acres in Bartholomew, Brown, and Johnson counties although about four-fifths of the camp is in Bartholomew County.

Camp Atterbury added to the labor supply of the Columbus' industries primarily by three methods: (1) In the site selected for the camp were about 700 families who had to sell their farms. So about 700 families were faced with no means of earning an income; consequently many obtained employment in industry. (2) During the period of extensive operation the camp averaged about 25,000 soldiers. Many of these men lived "off post" with their families in Columbus and since the war has ended many have stayed in Columbus and have gained employment in industry. (3) Camp Atterbury employed about 14,000 carpenters, plumbers, painters, and other types of construction workers to get the camp into operation. Many stayed in Columbus after the construction work was completed and today they are a part of the industrial labor supply. So Camp Atterbury has been a part of the reason for the excellent labor supply which has been helpful in the notable industrial expansion of the city.[4]

Market Areas

Columbus is centrally located for marketing the finished products. Many of these products are sold within Bartholomew County as many industries are dependent upon local consumption as a principal market. However, most of the metal industries supply finished products to various mid-western cities. Indianapolis, Chicago, St. Louis, Cincinnati, Louisville, Cleveland, Dayton, and Detroit are all market areas for varous industries of the city. One industry has attained such marked customer diversification that it supplies every volume builder of cars and trucks with at least one item for standard equipment.

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[2] Of the returned questionnaires from industrial concerns, a favorable location for the securing of raw materials was the most frequently mentioned advantage of Columbus as a permanent location for their industrial concern.

[3] One employer estimated that about forty percent of the city's employees are from out of town.

[4] In the questionnaire returns, a good labor supply was the second most frequently mentioned advantage of Columbus as a permanent location for their industry. Only two industries listed labor as a disadvantage and each stated that there was a tight labor market in the city. Both companies paid less than the average wage for labor in the city.

Transportation

Columbus is located on United States Highway 31 which extends from the Gulf of Mexico at Mobile to the Great Lakes at Chicago;

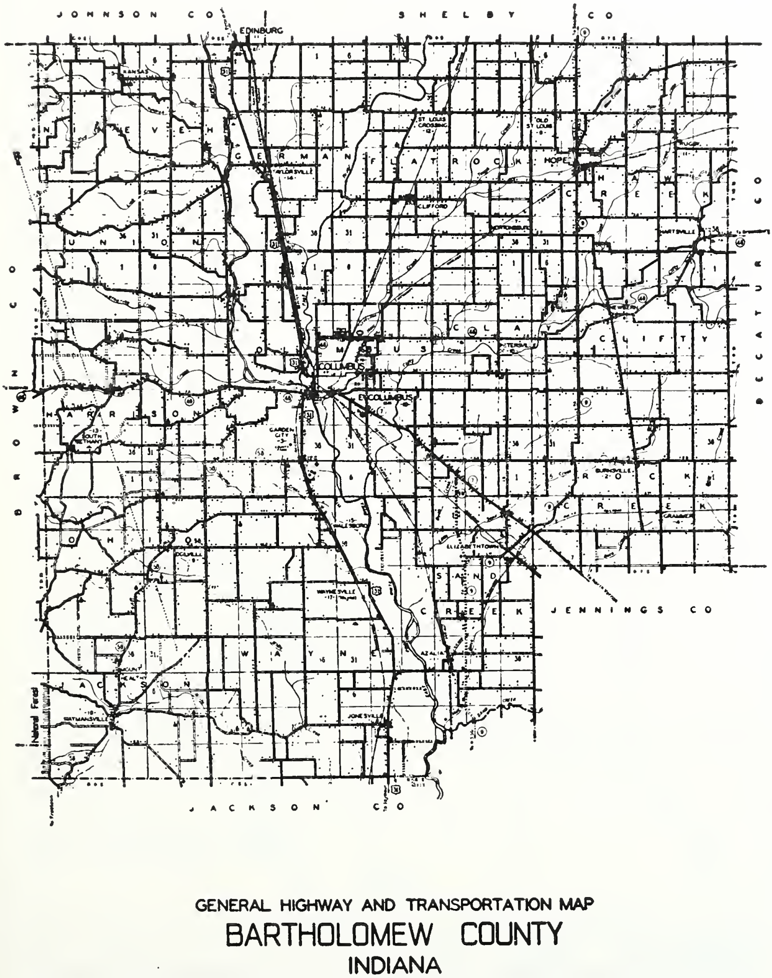

Fig. 3. General highway and Transportation map of Bartholomew county.

also, State Highways 46, 7, and 58 converge at Columbus, and State Road 9 begins near the city and extends into Michigan (see Figure 3). With these highway facilities, nine truck routes, and six bus routes pass through the city.

Today the most used method of transporting raw materials to the industries is by truck. One reason for the predominant use of trucking facilities by the local industries in the excellent highway facilities, and numerous industries own a major part of their trucking facilities. The

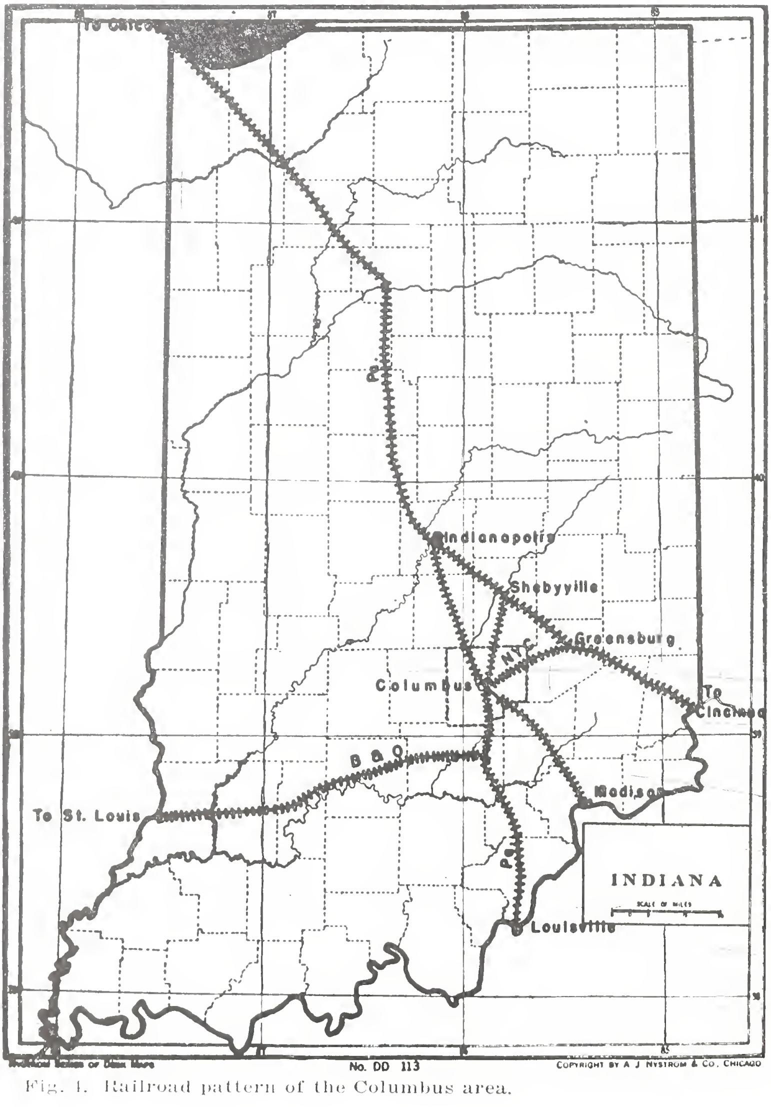

Fig. 4. Railroad pattern of the Columbus area.

good road system converging at Columbus is indicative of the desirability of its location and also of the transportation facilities required to service its needs.

Columbus is also located favorably in regard to railroads, since it lies on the main line of the Pennsylvania Railroad which runs from Chicago to Louisville and is also located on the Madison and Richmond branches of the same railroad (Figure 4). The New York Central Railroad extends from Columbus to Greensburg, where it joins the main line from Chicago to Cincinnati.

Railroads are used by the industries to almost as great a degree as the trucking facilities. Most industries consider the railroad facilities of Columbus to be good, although some complain of the high cost of transporting raw materials from the eastern part of the United States. Also, a few other concerns mentioned the fact that the rates to Columbus were not as low as they were to some other nearby but larger cities.

Tax and Utility Rates

The tax rate of Columbus in 1944 was $3.30, in 1945 and 1946 was $3.72 but increased to $5.02 in 1947. The average of other Indiana cities of similar size was $3.91 in 1944, $4.14 in 1945, and about $4.50 in 1947. The sharp increase was caused by the city's attempt to construct and repair streets, change the source of city water, install a sewage disposal plant, and repair or replace other municipal facilities. Since the tax rate was below the average for Indiana cities of similar size before 1947, tax rates were also a definite locational advantage.

The city's utility rates are about the average for Indiana cities, and industrial concerns no longer consider them an advantage, as they were for several years; although since they are about average they are not a serious disadvantage.

City Benefits

One of the most striking evidences of the thriving economy of the city is the large class "A" residential districts (see figure 2). The newer, more expensive houses are located in the northern portion of the city, and are largely homes of industrial officials. However, the unusually large portion of the city in class "A" homes is not the only benefit derived from the recent industrial expansion. Other benefits are: (1) Employment for the people of the city and surrounding area. (2) Increased buying power for the city and its population. (3) City improvements made possible. (4) Industrial diversification, and (5) decreased individual tax load.

The Electric Light and Power Industry of Indiana

R. K. Cassell, Indiana University

The State of Indiana is one of the ranking producers of electrical energy and its companies operate in parallel with an interconnected system of twenty-five power producers which supply Northern Kentucky, Indiana, Southwestern Michigan, Ohio, Western Pennsylvania and West Virginia. About thirty percent of the United States total weekly power output is generated in these states. Nationwise the State of New York, with generating capacity of 5,500,000 K.W. leads the major producers, with Indiana standing seventh with 1,700,000 K.W. at the end of 1947.

Before the turn of the century it could fairly be said that there was no electric light and power industry in Indiana. To be sure electrical energy was produced but not as a commodity for sale. A few factories generated electricity to power machines which might be used in the manufacture of household goods or farm implements; the South Bend railroad powered a street railway with electricity; and some cities had installed electric lighting systems. But not until after 1900, when the problems of distribution of energy had been solved, did the industry develop in Indiana.

Until World War I Indiana was far behind the surrounding states in production of electrical energy but by 1920 she had increased generating capacity to within a third of that of her most important neighbors. From 1920 to 1940, despite eight depression years, generation capacity more than doubled. Although, still a third behind these most favored neighbors in electrical generation capabilities in 1940, the available consumer supply of electric energy in Indiana was far above that of any of the adjoining states. In fact, it was said by some that the electric light and power industry in Indiana was over built.

It was this adjudged fact which led the Office of War Utilities and the Office of War Production to place such a quantity of war production contracts within the state that Indiana had the singular distinction of having the highest per capita war production in our Union from 1942 through 1945.

At the war's end, general industrial production slumped while generating capacity stood by. But the duration of production decline was not for long—not long enough for the electric light and power industry to replace old worn out equipment, or for making necessary repairs in the midst of a situation where metals and parts used in the electric industry were in very short supply.

During the first quarter of 1946 the demand for electricity increased to such an extent that the industry was called upon to supply more electrical energy than was safely available. Because electrical energy cannot be stored, generating plants must be large enough to supply power in amounts equal to peak load requirements. Furthermore, in order to guarantee a firm supply, and to be able to meet emergency situations, it is producer policy to provide a plant with 15 percent more generating capacity than is required of it during the peak load intervals. It is this margin of reserve between load and capacity[1] which has helped to supply the increased demand and many times this margin has been dangerously small. Hence, from time to time warnings are sent out about power shortage, and the larger consumers are asked to shift intervals of maximum consumption to off-peak hours.

Plants now under construction and new plans in progress warrant a substantial future increase in generation capacity. It is quietly accurately estimated that the amount of available energy in Indiana by 1950 will be double that of 1940.

Characteristics of the Industry

The industry is composed principally of six operating companies, namely Public Service Company of Indiana, Southern Indiana Gas and Electric Company, Indianapolis Power and Light Company, Indiana Service Corporation, Northern Indiana Public Service Company, and Indiana and Michigan Electric Company.

The sites of power generation are concentrated either in areas of maximum consumption or at points of low cost of production. While the map (figure 1.) shows that there are wide areas without generating capacity, it also indicates the transmission system over which power is distributed throughout the state. The trend of bringing power to the worker has been so strong in Indiana that it has been one of the leading states in bringing about the industrial revival of the countryside.

Besides the intricate transmission and distribution system of the several commercial companies is the potent factor of integration. There is a complete system of interstate as well as intrastate inter-connection. Such tie ups permit a company, for instance, to purchase power needed at peak load intervals, and at other times to dispose of surplus power, and provides mutual aid for all companies in times of emergency.

There are 84 municipal plants in the state with only one generating as much as 25,000 KW. Fifty-four of them buy all their power from the commercial producers. Among the larger municipal plants such as Anderson, Richmond, Crawfordsville, Logansport and Goshen, to mention the most representative cities (figure 1.), power is drawn from the utilities' transmission system, either to reinforce firm supply or for standby emergency use. The twenty odd smaller municipal plants have

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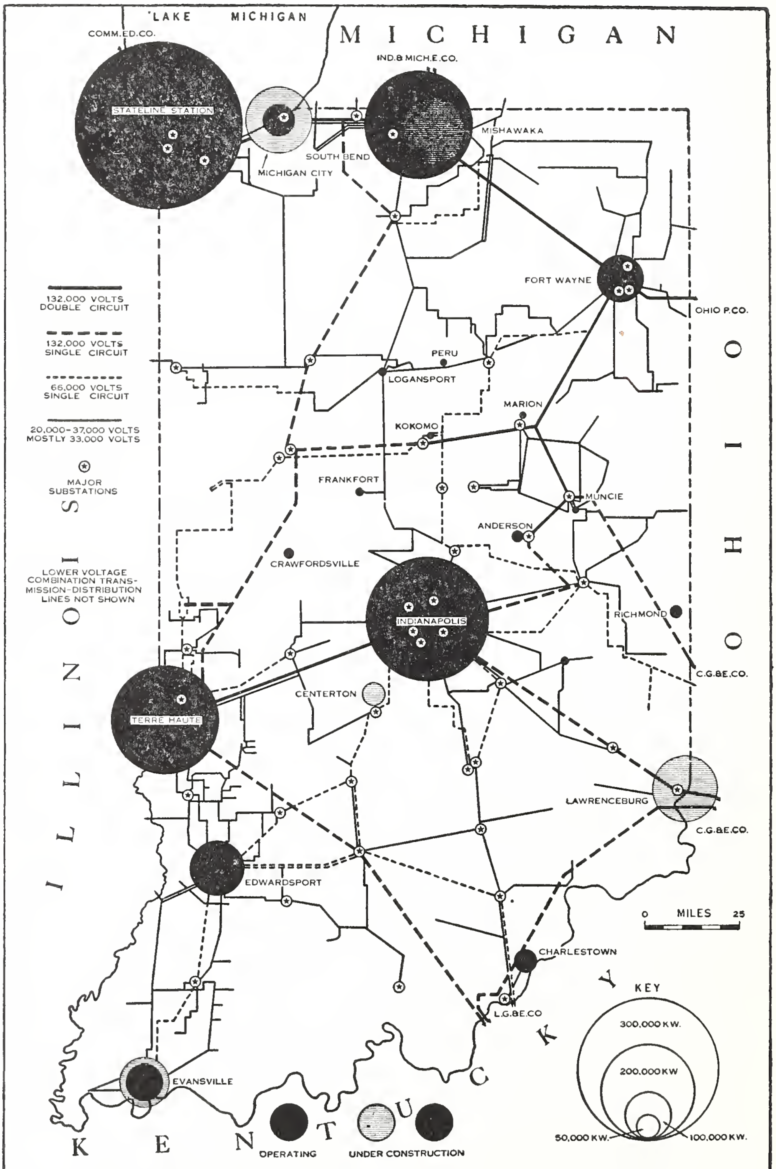
[1] Data on generating capacity is almost always shown in terms of manufacturers' "name plate rating"—the capacity which the manufacturer will guarantee. Usually, due to differences in operating conditions, or to modification after installation, the actual capacity is quite different, mostly higher than the nameplace rating. This unrecorded capacity plus the fact that most generators are capable of carrying considerable overload for a period of time have more than once prevented derangement of service during the period of short supply.



GENERATING CAPACITY AND ELECTRIC TRANSMISSION SYSTEM IN INDIANA

capacities mostly under 10,000 KW., and the sum of generating capacity of all the municipal installations is only about 175,000 KW.

The consumers of electricity in Indiana, statistically divided into residential and rural, small-commercial, large industrial, and traction companies, embrace or include the greater proportion of human activity. Large industry consumes almost sixty-five percent of total kilowatthour produced with small commercial and residential and rural using around fifteen percent each, and traction companies consuming about five percent. While only eighty-five percent of our farms have been electrified, further development in this field is toward installation of larger transmission systems as farms become greater power users, rather than electrifying farms without service. Today the farms that do not have electricity are largely of the sub-marginal, self-sufficiency type and, therefore, would be little benefited by such service.

Cost of Electricity

To the consumer the cost of electrical energy, for the state as a whole, does not exceed the average of that of any neighboring state. According to the most recent series of index numbers published by the U. S. Bureau of Labor Statistics, in which the average of the five years, 1935-39, is used as the base, the cost of residential electricity stood at 89.0 in December 1947, compared with a Cost of Living, on the same base, of 167. While sales of electricity throughout the decade have increased tremendously with the resultant decline in average price of Kwhr sold, the rapid postwar increase in the trade's basic costs, plus the burdensome financing of expansion projects, will inevitably force consumer prices upward.

Most electric generators in the state are powered by steam, with coal as the principal fuel. Abundant and cheap coal has favored this type of prime mover of the generator. Moreover, Indiana's topgraphy and river regimen are such that the cost of construction of sizeable hydro-electric plants would be comparatively much more expensive. Consequently, almost ninety-two percent of the electrical energy produced today comes from the steam driven generator.

Conclusion

The electric light and power industry after a late and slow start has grown to proportions which has attracted many heavy power consuming industries with the result that a power shortage became a serious threat. But now programs are under way to establish the normal reserve of plant and equipment and promote general growth of the industry. Supplied mostly by large operating companies, no urban and practically no rural population unit in Indiana is now without service.

Hudelson Cavern, A Stormwater Route of Underground Lost River, Orange County, Indiana

CLYDE A. MALOTT, Indiana University

Drainage Characteristics of Indiana Caverns

The limestone caverns of Indiana are features of subterranean drainage, though many of them are now above drainage level and are dry. The relationship of many of the dry caverns to their former sources of water supply is relatively obscure, chiefly because only remnants of their courses are available for study and too little is known about their actual linear ramifications. Numerous caverns in the limestone region of southwestern Indiana, however, are still the routes of subsurface drainage, though only a few of them may be explored through much of their courses. Many of the stream-coursed caverns have definite relations to their sources of water supply, while some have rather obscure relations. Most of the stream-coursed caverns get some of their waters from seepage through the general overlying and contiguous bedrock which slowly feeds clear waters into them, mainly through joint controlled routes. Such a supply of waters to the cavern streams is relatively continuous and uniform. These caverns are usually developed close to drainage level and their courses, except in a few cases, may not be followed far. But many of the stream-coursed caverns of the limestone belt receive surface waters from definite places of intake, and their stream volumes are subject to rainfall and drainage variations. These caverns in addition to their flows of clear groundwater, are subject to the excess waters of rainy periods, and the stormwaters fed into them from the surface may be charged with muds, silts, sands and gravels. Such caverns may be entered only during dry periods when their water flow is relatively small. Some of the stream-coursed caverns carry only stormwaters and have intermittent flows of water. Such caverns occasionally have higher levels which are subject only to the influx of storm-born waters which over-tax the lower routes, and occasionally they may have dry sections completely above the inflooding storm-born waters.

Nearly all of the better known caverns of southern Indiana are stream-coursed with the exception of Marengo and Wyandotte caverns, and most of them carry storm-born waters entering at definite places of intake. As such they are the routes of underground drainage. Many caverns are completely sealed and carry both ground and storm waters. Their terminal ends are the sites of large springs which are at or slightly below drainage level and cannot be entered. Many caverns, however, terminate above drainage level and open widely at their lower ends. Porter's, Boone's, Ray's, May's, Donnehue's, Hamer's, Donaldson's, and the Clifty caverns are examples which discharge their waters through relatively large openings that in large part are above drainage level. Only a few caverns in southern Indiana may be entered at their upper ends where they receive their surface waters. The American Bottoms caverns of eastern Greene County and Eller's and Saltpetre caverns of western Monroe County are examples. In many cases entrances to caverns are through sinkholes which may open directly or indirectly into the cavernous routes. Entrances to the underground Lost River at Wesley Chapel gulf, the Tolliver gulf, and Hudelson cavern are examples. Trinkle cavern, near Hardinsburg, Washington County, is a collapse sinkhole entrance to Sinking Creek, Marengo cavern was originally entered through a sinkhole. The Donaldson cavern system of the Spring Mill State Park may also be entered at two different places where sinkhole breakdowns have occurred.

Stream-coursed caverns, especially those which carry gathered stormwaters from the surface, offer little attraction as scenic features and are seldom visited by the public. Only a few of them have been described in detail, and still scantier attention has been given to them as subterranean drainage routes. It is the purpose of this paper to present some of the details of a stormwater course of underground Lost River, locally known as the Hudelson cavern. This cavern was entered and mapped by the writer and Robert Shrock in August, 1929, during a study of the Lost River region of Orange County. Few people know about the presence of the cavern and only a small number have been in it. It is an unattractive, muddy cavern, and in addition may be considered dangerous.

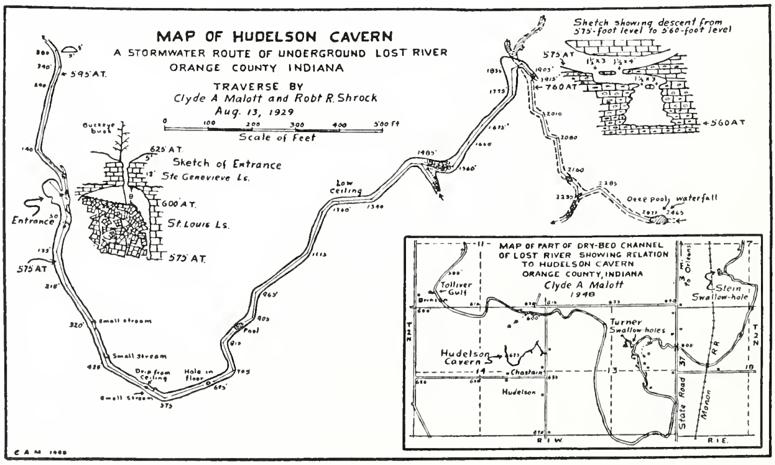
Lost River Drainage

Lost River, carrying waters from 53 square miles of drainage, sinks in various small and several large swallow-holes along its middle course. Its first sink is a small one in the SW ¼ of sec. 4, T. 2 N., R. 1 E., about two miles southeast of Orleans. This sink carries all of the water fed into it during rather dry periods and marks the very beginning of the dry-bed channel. During much of the year, however, Lost River sinks in several rather well defined but shallow swallow-holes west of the center of sec. 8, about one mile farther down stream. If rains overtax the capacity of these swallow-holes, the excess waters enter various swallow-holes farther down stream. The Stein swallow-hole in the SW¼ of sec. 7 has a large capacity, but heavy rains send stormwaters beneath the bridge on State Road 37, about three and one-half miles south of Orleans, and on to the Turner swallowholes in the NE¼ of sec. 13, T. 2 N., R. 1 W. Still heavier or continued rains send the waters throughout the winding course of the dry-bed channel which is more than 20 miles in length. The rise of the underground stream is on the Allen farm, near the center of sec. 7, T. 2 N., R. 1 W., about three-fourths of a mile south of the village of Orangeville. The direct distance between the first swallow-hole and the rise is about 8 miles, but the underground course is undoubtedly much longer.

Very little is known about the underground course of Lost River. It is probably not a simple underground course, but is characterized by many channels developed along routes hewed out from the joint system in the upper part of the St. Louis limestone in which it is developed. This complex system is well illustrated in the explored routes of the underground system at Wesley Chapel gulf where it has been partially mapped and described by the writer in a special paper written in 1931. The underground routes in the region of the first sinks are but little below the surface channel, but descend to as much as 30 feet below the dry-bed at the Turner swallow-holes. They are as much as 40 feet below the dry-bed at the Hudelson cavern and at Tolliver swallow-hole to the west. In approaching the rise of the underground stream, the dry-bed is cut deeply below the general sinkhole plain and the underground channel or channels are only slightly below the dry-bed. During flood periods, however, the system occupies levels much above the low water routes, coursing through levels as high as the dry-bed itself. The underground system has both low and high water levels. At the Hudelson cavern and the Wesley Chapel gulf these have a vertical range of 40 feet or more.

Name and Location of Hudelson Cavern

The Hudelson cavern takes its name from a former owner of the farm on which the sinkhole entrance is located. The land is now owned by Austin Chastain. The entrance is in the east part of the SW of the NE¼ of sec. 14, T. 2 N., R. 1 W., about midway between Orleans and Paoli and about one and one-half miles west of the bridge across the dry-bed channel on State Road 37. It is 360 yards north of the Chastain residence and 550 yards south of the dry-bed channel of Lost River. See inset map of figure 1. The Hudelson cavern is in the midst of the sinkhole plain through which the dry-bed channel of Lost River passes. Entrance to the cavern is attained through a small sinkhole at an altitude of about 625 feet, some 25 feet above the level of the dry-bed of Lost River. The relief of the sinkhole plain is relatively small



though in about one mile to the south the edge of the rugged Chester escarpment rises as much as 200 feet above the sinkhole plain, exceeding 800 feet in altitude. The cavern itself is developed at three levels beneath the sinkhole plain. The cavern floor immediately beneath the entrance is about 25 feet down. A small high-level channel extends northward at an altitude of about 595 feet. The middle floor is at an altitude of 575 feet. The lowest floor, at or near the permanent watertable, is at 560 feet in altitude and lies 60 to 100 feet beneath the undulating sinkhole plain. All the floors of the cavern are developed in the St. Louis limestone, though the uppermost floor is near the contact with the Ste. Genevieve limestone which composes the surface lands of this part of the sinkhole plain.

Description of Hudelson Cavern

The sinkhole entrance to the Hudelson cavern is a small one. It is about 15 feet across and depressed only about 5 feet below its rim. It is marked by a buckeye bush which grows at the edge of the open hole in the bottom of the sinkhole. The opening in the sinkhole is about 2½ feet across. It extends vertically downward through 12 feet of rock to the ceiling of an expansive room 8 feet above a rather flat floor. The room is approximately 40 feet across in an east-west direction. It extends northwest 45 feet where the ceiling descends to the floor. The land floor of the room is composed of blocks of mud-covered rock, indicating that the muddy stormwaters of underground Lost River cover the floor. They do not reach to all parts of the ceiling of the room. Southward the floor descends slightly and in about 75 feet descends abruptly into muddy pits into which stormwaters from the south disappear during high-water periods. This east wall of the room is composed of thick bedded layers of rock, and the floor, composed of mud-covered fallen blocks of rock, abuts closely. The wall, however, descends about 25 feet to the 575-foot level of the cavern. Northward, a rather small passage was followed for about 400 feet at an altitude of 595 feet. It is a high-level escape route of stormwaters at or near the level of the dry-bed channel of Lost River. It's floor and ceiling are rather irregular and in places the passage itself is rather constricted. Everywhere the route indicates the northward passage of muddy stormwaters. At 380 feet from the entrance the passage was only 3 feet high and 5 feet wide and was not followed farther.

Southward 75 to 100 feet from the entrance the 575 foot level of the cavern is reached. A stream channel with a mud wall on one side and the massive rock of the cavern on the other side terminates in muddy pits and against the blocks of rock composing the platform of the entrance room. This channel is continuous with the 575-foot level throughout with few interruptions. The stormwaters when present apparently enter the pits and in part go around the east wall of the entrance room and thence northward down the high-level passage. The 575-foot level extends south-southeast for a distance of 575 feet, where it turns northeastward. See traverse map, figure 1. A little water trickles along on the narrow floor of the mud channel. This channel is 5 to 10 feet in depth and the cavern ceiling is 5 to 15 feet above its floor. The cavern itself is 12 to 25 feet in width. A small trickle of water enters from the east (left side) at 320 feet from the entrance, and another at about 400 feet, and still another at about 540 feet. Water drips noisily from a hole in the roof at 525 feet and a shallow plunge pool is present in the mud floor here.

After turning northeastward the narrow bottom of the mud channel is directed into a small hole in the floor at a distance of 675 feet from the cavern entrance. The northeastward stretch of the mud-floored channel shows little change. It turns slightly here and there and the mud wall is first on one side of the cavern and then on the other. The cavern ceiling is slightly uneven in an undulating manner, but is not rough. It is usually 6 to 9 feet above the mud floor of the channel The cavern sides are 12 to 20 feet apart, averging about 15 feet. The rock everywhere is covered with mud. The mud surface is minutely uneven, and locally resembles berries. An occasional stalactite is present here and there, also well covered with mud. Nowhere does rock show on the floor of the cavern.

At 1,270 feet from the entrance the cavern is so filled with mud that it is necessary to crawl for a distance of about 120 feet. Here the roof is 2 to 3 feet above the shallow mud channel of the floor. At 1,485 feet from the entrance the mud channel becomes double, one channel coming from the left (nearly due east) and the other coming from the right (southeast). The cavern widens into a room about 60 feet across. The channel on the right comes out of broken-down rock next to the right wall of the cavern. It did not appear big enough to enter, and no attempt was made to follow it. The channel on the left comes through broken-down rock, and a ridge of mud rises sharply between the two channels. The left channel was followed by going over mud-coated rock slabs adjacent to its right wall, and in about 75 feet the mud channel was again entered.

The mud channel continues northeasterly to a large room 1,835 feet from the entrance to the cavern. The ceiling of the room is 15 to 20 feet above the floor, and on the northwest the mud floor rises to the ceiling in a distance of about 40 feet. It seems probable that the main cavern once extended in that direction, but has been completely sealed off by accumulated muddy silts. A hole above allows water to fall into the room, and a ditch-like channel leads from the plunge basin southeasterly under the rock ceiling to a lower level. Apparently surface waters enter here during rains. At the southeast end of the big room, close under the ceiling, ragged holes in the rock floor lead to the low-level route of the cavern developed at an altitude of about 560 feet. These holes are 1,905 feet from the entrance of the cavern. It is quite apparent that stormwaters fill the lower route to its full capacity and then rise through the holes and flood the next level above.

The 560-foot level is at or near the permanent watertable of the region. It extends in a northwest-southeast direction. It is developed in a very cherty phase of the St. Louis limestone and presents a rough and ragged appearance as a cavern channel. Rough cherty masses extend from the walls and ceilings, and the floor is partly covered with loose chert masses. Excavated holes in the floor add to the unevenness. The storm waters appear to pass through the cavern with great force in a northwest direction. The rugged route is 6 to 10 feet in height and 10 to 15 feet in width, with occasional wider places. A mud coating is present on the walls and ceiling, but the floor is relatively free from mud.

After descending through the ragged holes to the lower level, the passage was mapped northwest in a downstream direction. At a distance of 70 feet, a pool of clear water was encountered measuring 5 feet or more in depth with a ceiling only 2½ to 3 feet above the water. The passage turns slightly to the right and could be observed for only 30-40 feet beyond the end of the traverse. Upstream from the entrance holes the low-level cavern route was mapped for a distance of 550 feet from the entrance holes and 2,425 feet from the entrance to the cavern, where the traverse was stopped by a pool of water occupying a plunge basin beneath a waterfall ledge 3 feet above water level. A blind fish fully 5 inches in length was observed in the clear water of the pool. At 320 feet from the entrance holes, a lead goes off to the right (south-southwest). It is smaller than the main channel and is nearly filled with loose rock. Apparently stormwaters from the main channel feed into it. Ripple marks and etched rock clearly indicate water passage into it. It's floor 75 feet back from the main channel is considerably higher than that of the main channel. It is possible that the waters which follow this lead are fed into the 575-foot level in the room 1,485 feet from the sinkhole entrance to the cavern system.

Stormwater Drainage in Hudelson Cavern

The Hudelson cavern was entered and explored in the hope that it would lead to the low-water route of the main channel of underground Lost River. It seems quite probable that the explored part of the cavern is south of the main route. The 560-foot level, however, very probably leads directly into it. Swallow-holes in the dry-bed just to the north of the cavern are directed southward from the dry-bed, evidently leading into the underground route of Lost River somewhere between the mapped part of the cavern and the dry-bed channel. The cavern was again entered during a dry period in June, 1931, and a further attempt was made to trace the low-level route to the main course of underground Lost River. The route was extended for 100 feet or more by wading through water varying from knee to waist deep, avoiding the deeper places. Numerous white blind crawfish were noted and two blind fish up to four inches in length were observed in the clear water. The walls of the cavern are very rugged with chert masses, and the ceiling is irregular in height, varying from a few inches up to 10 feet above the water. At the end of the traverse the ceiling came down to within a few inches of the water, but beyond it could be seen to rise again over rather deep water. The total traverse of the cavern system aggregated 3,200 feet.

The stormwaters which course through the triple-floored Hudleson cavern rise as high as 605 feet in altitude, as much as 45 feet above the low-water route at or near the watertable of the region. There are two possible sources of these stormwaters. It is possible for them to come from the surface streams which descend from the Chester escarpment south and southeast of the cavern, where several ravines send their rain-born waters into individual swallow-holes on reaching the sinkhole plain. These waters undoubtedly reach into the underground system of Lost River, though their actual routes are unknown. The second possible source of the muddy stormwaters is from the dry-bed channel of Lost River entering through the numerous Turner swallow-holes near the center of the NE¼ of sec. 13, about one mile east of the cavern entrance. See in-set map, figure 1. It appears quite probable that this is their source. The traverse of the cavern system ended at the up-stream end 1,400 feet nearly due east of the cavern entrance and directly toward the area of the dry-bed swallow-holes. It is regrettable that the traverse was not continued in this direction in spite of the deep pool of water which discouraged further exploration. This source is highly adequate, and the behavior of the waters flowing through the cavern system seems to indicate such a source.

It is apparent that the stormwaters course through the cavern with considerable velocity during an early period of flow, but later the waters become stagnated or flow very slowly. The high velocity period is associated with a filling period when large quantities of water enter the Turner swallow-holes from the dry-bed. Later, the underground routes become filled with stormwaters and the velocity of flow is checked, chiefly because of the stormwaters entering the lower part of the system down-stream. These waters in their use of the down-stream part of the underground system partially block the waters in the up-stream part. Decreased volumes then enter through the swallow-holes in the upper part of the system, and the excess stormwaters descend down the dry-bed channel. The stagnated muddy waters deposit muds in the underground routes of the system, especially in the higher levels, such as the 575-foot level of the Hudelson cavern. The walls and ceilings become heavily coated with mud and dead-end channels become filled. These waters stand as high in the system as the flood waters in the dry-bed channel and they cannot be evacuated until the dry-bed is lowered or emptied. Following the cessation of flow in the dry-bed, the stormwaters in the subterranean system subside and eventually cease to flow. Only clear waters seeping into the system from groundwater sources then flow through the lowest routes, except for the constant passage of waters from the upper part of the system which is spring-fed.

Conclusion

It appears quite likely that the compound vertical components of a system like that of Hudelson cavern are a result of the development of successive levels as the watertable is lowered, and that the older and higher levels are maintained and further developed by the inflooding waters from the surface. The upper levels are maintained as long as the underground tubes are not too much clogged by breakdowns in them, or as long as they are occupied by stormwaters passing through them. Later stages in their history are associated with incoming flood waters which do not flow freely because of occasional breakdowns in the passages which clog them. These stages are associated with accumulations of clays and silts brought in by the muddy waters which may fill the dead-end passages and largely eliminate them. Such clays are highly characteristic of dry caverns now above the reach of inflooding stormwaters and high above the watertable. New levels are initiated at or near the watertable by the normal phreatic waters along the permissive bedding planes and the joint system of the limestone. As such the initiated water passages are small and of little significance. When taken over by the high-pressure flood waters from the surface, they become enlarged and the selected routes of subterranean drainage are established from those more favorably located or which have more quickly become etched out and become subject to the inflooding of stormwaters gathered from surface areas. The caverns into which they develop are the result of subterranean drainage, not so much by the phreatic waters, but by the stormwaters directed into and through them.

Structural Trends of the Southern Flanks of the Wisconsin Arch

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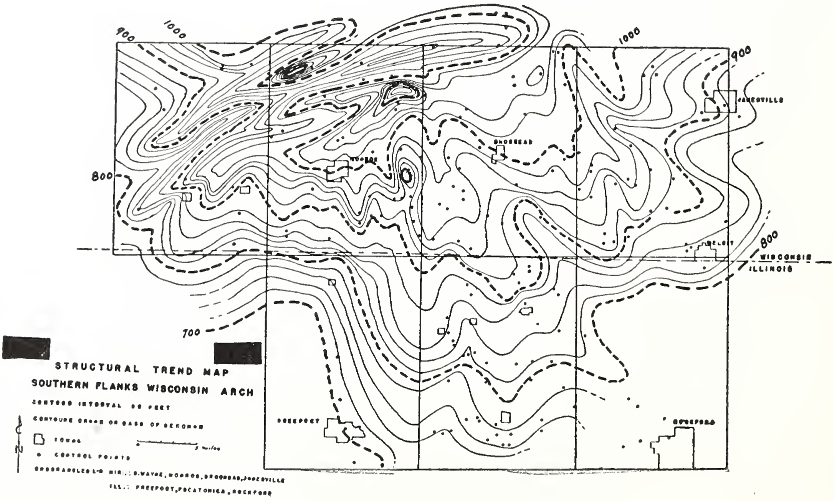
Areal geological maps of southern Wisconsin show the generalized broad pattern of the uplift in central and southern Wisconsin. The irregular areal map pattern in southern Wisconsin results mainly from erosion by streams in an area of near horizontal strata. Secondary cross structures are indicated when trend maps are drawn on a definite horizon.

The horizon chosen for mapping in the present paper is the base of the Decorah formation. Structural maps are drawn on the top of the Dresbach (1), top of the St. Peter (2), and for a small area in the Monroe Quadrangle on the top of the Platteville (3). The Decorah formation is here used for mapping because the shaly facies is generally present, the formation is near the surface in the area covered, and fossils of the upper Platteville and the lower Decorah can usually be recognized. Locally Decorah lithology simulates that of the Platteville formation below, and the Galena formation above. Elevations of Platteville-Decorah contacts are estimated from contour maps. Where formation contacts are few, covered, or not recognized, known horizons in the Platteville or Galena formations are plotted, and the proper number of feet added or deducted as the case may be. A fucoidal zone in the upper Platteville is helpful as a marker, as is a dwarfed form of *Receptaculites* in the upper Decorah.



The thickness of the formations is nearly constant. Eastward the Platteville thickens slightly, the Decorah remains at about twenty-five feet thick, while the Galena thins somewhat.

Alden's areal map (4) is used as a check, and in several instances, to mark elevations of contacts where outcrops are hidden beneath the drift.

The map shows broad anticlines and synclines gently pitching away from the main axial trace. Along the northern border of the area a sharp break in the contour lines exhibits cross structure trending southwest-northeast. Probable sharp flexures or faulting is indicated. North of the area several faults are mapped (5), striking in a like direction.

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Indiana's Geographic Regions

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Those who know Indiana recognize that it has sufficient regional contrasts to justify subdivision into at least a few regions. There is disagreement, however, as to how many merit distinctive names and as to boundaries. The present writer has made numerous maps which reveal contrasts in Indiana in respect to various environmental conditions and of responses partly there to. ("Climate of Indiana," 1944 has more than 300 maps: and more than two hundred additional original maps of other aspects of the state are presented elsewhere.) A detailed discussion of regionalization in Indiana appears elsewhere. (Annals of the Association of American Geographers.)

A study of the regions of Indiana has been made on the basis of numerous criteria, including geologic stratigraphy, glaciation, physiography, average elevations, local topographic relief, average amount of ruggedness, amount of soil erosion, types of soil, climatic contrasts, native vegetation, agricultural land use, average population density, urbanization and population changes. Maps are given elsewhere showing the regions which are discernable on these bases. Here, however, the major regions only are briefly described.

The three regions which are generally recognized are Northern, Central and Southern Indiana. These are based on a combination of differences in topography, soil, climate, land use, and historical development. Nearly three-fifths of the state is known as Central Indiana. It is generally a gently undulating glacial till plain, with poorly developed natural drainage and with numerous but mostly inconspicuous remnants of former glacial lakes. Its elevation is fairly close to 800 feet, on average about 650 at the west and about 900 at the east. The local relief is generally less than 100 feet. It's soil is largely a clay loam, and the sub-soil is scores of feet thick nearly everywhere. Central Indiana is part of the Corn Belt, one of the choice farming regions of the world. Much of it has been classed by the U. S. Department of Agriculture as Grade 1 farm land. Indiana possesses more acres of such very choice land than 30 other states combined. It comprises some of the best of the Corn Belt, with many thousands of officially recorded corn yields of more than 100 bushels per acre, and with a heavy production of tomatoes, and soybeans, and with numerous economically successful farms, many of them as small as 80 acres.

The northern one sixth of the state differs from Central Indiana partly in being less generally level, in having poorer natural drainage, in still possessing numerous glacial lakes and in having much more sandy soil. It also has numerous small areas of muck. It has less excellent farm land, on the average, partly due to the climate. Repeatedly in Northern Indiana, the frost-free season is not quite long enough for corn to thrive as well as it does in Central Indiana. The Corn Belt's northern margin is in Northern Indiana. Cold spells are more numerous and colder than in Central Indiana; snowfall normally is heavier. Northern Indiana was glaciated recently, by the Late Wisconsin Ice Sheet, and the glaciers left more conspicuous moraines, more lakes, more glacial boulders, and much more wide-spread deposits of sand than in Central Indiana. Northern Indiana was the last of the three great regions of the state to be extensively populated and it has grown most rapidly in population in the last forty years. Northern Indiana surpassed Southern Indiana in manufacturing about 1900, and recently has surpassed Central Indiana, despite the importance of Indianapolis, which contains about as many people as the three chief northern cities combined. Dairying is extensive in Northern Indiana, and the growing of truck crops, especially potatoes and onions.

Southern Indiana, approximately the southern fifth of the state, contains most of the state's hilly land, although parts of Northern Indiana are moderately hilly, as are small parts of Central Indiana. About half of Southern Indiana was not glaciated and the remainder was glaciated mostly relatively long ago (by the Illinoian Ice Sheet). The contrast in elevation is locally the greatest in the state (400 to 600 feet for a few counties). The soils of Southern Indiana average poorer than in Northern and especially poorer than in Central Indiana. Soil erosion has been notably greater, partly because of the greater average slope, the thinner soil, and the longer period of settlement. (Southern Indiana was the first region settled.) Significant also are certain regional climatic contrasts. Southern Indiana has more precipitation, especially in the cooler months, it has more torrential rainfall, much more in winter; it also has less snowfall and frost protection of the soil. Most of the people of Southern Indiana are supported by agriculture, though manufacturing is extensive in Evansville and, considerable, in proportion to their population, in several smaller cities. Coal mining is significant in several western counties. Nearly half of Southern Indiana is woodland or prospective woodland. Most of the counties of Southern Indiana have fewer people now than they had in 1890; several have declined in population since about 1870. This decline has been due partly to the general depletion of lumber, and also of top-soil. Very significant however, have been the improved opportunities available in Central and Northern Indiana and elsewhere, and the desire for more income than could be obtained from most of the farms of Southern Indiana. Of not least importance in causing the decrease in population has been a general reduction in the size of the average family.

Despite the fact that the cores of each region differ significantly, no distinct line of demarkation is observed when crossing from one region to the next. Hence the boundaries are drawn in different places, depending on what criteria are deemed of special importance. The most important basis for these regions has often been considered to be glacial. Northern Indiana was most recently and most strikingly glaciated, Central Indiana was notably affected by an earlier ice sheet, but most of the glacial effects are less obvious. The core of Southern

Indiana was not glaciated, and the rest was glaciated relatively long ago, with most of the effects not inconspicuous.

Subdivisions of Northern, Central and Southern Indiana

Each of Indiana's three major regions can advantageously be subdivided. Northern Indiana is distinctly different at the west than at the east. In the west, sand is widespread, and there are numerous sand dunes, including the fine ones along the shore of Lake Michigan and several rows of lesser ones along the former shores of the ancient enlargement known as Glacial Lake Chicago. In the east, by contrast, there is almost no sand, but instead relatively high morainic hills and deep hollows, with numerous lakes. Marshland is extensive at the west, including the Calumet and Kankakee marshes, but lakes are few. Western Northern Indiana differs climatically from eastern partly in having dryer winters, more drouths and more frequent sub-zero temperatures. The middle part of Northern Indiana, the area just east and southeast of the end of Lake Michigan, receives notably more snowfall than the rest of the state. The Northwestern corner of Indiana also differs from the northeastern industrially, as it is an eastern extension of Chicago, while little manufacturing is done north of Fort Wayne or east of Elkhart.

In Central Indiana, the contrasts between the eastern and western parts are less than in Northern Indiana, as much of the region generally is almost level, with relatively little soil contrast, except that part of the west has black prairie soil. However, partly due to differences in elevation, there are perceptable climatic contrasts. As the eastern third of central Indiana averages nearly 300 feet higher than the western third, the nights are appreciably cooler, especially during the warmer months, there is a shorter growing season, the clouds hang lower in winter, and the snow-cover remains longer. Eastern Indiana also receives more precipitation in winter, has less frequent drouths and fewer intense thunderstorms. In the development of the state, the discovery of extensive gas and oil in the eastern part of Central Indiana in the late 1880's, and 1890's, but only locally elsewhere, was significant. It led to the rapid growth of several towns in the "gas belt" into manufacturing cities. Conversely, coal is extensive in much of the western counties of Central Indiana but not elsewhere in the state, except in western Southern Indiana. Coal has been a significant influence in the development of the areas where it has been extensively mined.

In Southern Indiana, there are notable contrasts. The western fourth, approximately, is the Wabash Lowland, with extensive, fairly level tracts and the lowest average elevation in the state (much of it 400 to 500 feet above sea level). The growing season is the state's longest, the night temperatures highest, snowfall least, rainfall heaviest, and there is most winter sunshine. That section is also mostly underlain with coal, and numerous scattered small areas have yielded oil or gas or both. Most of the Wabash Lowland is good farming land where corn growing is extensive and melons locally important. The soil is partly loessial, partly lacustrian and extensively alluvial.

To the east of the Wabash Lowland is a broad zone of steep hills developed on sandstone, with generally poor soil. It has few people and much wasteland. Next east is a "limestone valley" averaging about 15 miles wide, notably less rugged than the zone just mentioned but by no means flat. It contains myriads of limestone sinkholes and some sharp hills; indeed some of it has a mild "karst topography." There are numerous caverns, one glamorized as "Lost River." Its soil and topography are, however, better than in areas adjacent to the east and west. The Monon Railway follows this "Valley," which contains several small cities, including Bloomington, Bedford, Paoli and Salem. This is the "Indiana Limestone Belt," yielding much of the nations cut building limestone. The next zone east is a hilly upland developed on shale, with generally rather poor soil. The eastern margin of this upland forms "The Knobs," a picturesque line of high hills and bluffs as seen from the lowland just east. This lowland is the western margin of a gently sloping belt which extends from near the eastern margin of the state. This eastern slope was glaciated, but so long ago that any morainic clay remaining has been badly leached, and erosion has proceeded extensively. Indeed soil erosion is severe in all of southern Indiana but the small flat areas

Thus, in brief, despite Indiana's small size (36,000 square miles) and slight range in elevation (from 313 to 1285 feet) it possesses clearly discernable regional contrasts. Hence a summary of the average characteristics of the various subdivisions of the state contributes to understanding.

HISTORY OF SCIENCE

Chairman: S. S. Visher, Indiana University

Paul Weatherwax, Indiana University, was elected chairman for 1949.

ABSTRACTS

The Wabash Academy of Science, Will E. Edington, DePauw University.—The Wabash Academy of Science was organized at Crawfordsville, in 1844. According to it's *Proceedings of the Eleventh Annual Meeting,* held in July, 1854, it had a membership of fifty-eight, including Ryland T. Brown, John Campbell, William Twining, J. S. Roughum, and others then prominent in Indiana science.

The Terre Haute Scientific Association, Will E. Edington, DePauw University.—The Terre Haute Scientific Association was active for some years in the 1880's. Its membership included members of the faculties of Rose Polytechnic Institute and of the Indiana State Normal School. In 1888 it sponsored a "microscopical Soiree," which lasted two evenings, at which twenty-seven displays of microscopic studies and specimens were presented.

The Second Decade of Purdue University's School of Pharmacy, C. O. Lee, Purdue University.—The present paper continues the one presented before the Academy last year on the first decade. During 1894-1903 the school of pharmacy first offered a two-year course leading to the degree of Pharmaceutical Chemist, and a four-year course leading to the degree of Bachelor of Science in Pharmacy. Purdue was thus among the leaders in offering the bachelor's degree in pharmacy. The paper also reports faculty personnel from year to year, curriculum changes, enrollment, and the number graduated.

Indiana Geologists Before 1900, Clyde A. Malott, Indiana University.—The geology of Indiana has been the subject of study by a few geologists whose names are famous in American geology, but the presentation of much of the field details has been the work of local geologists. This is true not only for the period up to 1900, but up to the present time. J. P. Leslie and F. H. Bradley worked briefly in Indiana in 1859 and 1869, respectively. Leo Lesquereux, S. A. Miller, C. A. White, E. D. Cope, and James Hall contributed notably to the paleontology of Indiana in the 1870's and 1880's. Lesquereux was on the second Owen survey in 1859 and made a notable contribution to the knowledge of the coal bearing formations. Frank Leverett, T. C. Hopkins, and G. H. Ashley presented much field detail in Indiana geology in the 1890's. All of the official State Geologists of Indiana have been residents of the State and their reports constitute voluminous details on Indiana geology. D. D. Owen of New Harmony made a special geology survey of Indiana in 1837-38. A second special survey was made by R. T. Brown in 1851-53, and a third special survey was carried out by Richard Owen in 1859-61. E. T. Cox, also of New Harmony, was State Geologist for 10 years following the establishment of the Indiana Geological Survey in 1869. In the detailed county surveys of the Cox period, Rufus Haymond, John Collett, B. C. Hobbs, Robert Warder, W. W. Borden, M. N. Elrod, and E. S. McIntire did much of the field work for the Cox reports. John Collett followed as State Geologist and served until 1885. He employed the services of G. K. Greene, R. T. Brown, A. J. Phinney, D. S. M'Caslin, and M. N. Elrod. Maurice Thompson was appointed State Geologist in 1885 and served until 1888. His geological staff was composed of S. S. Gorby, A. J. Phinney, W. H. Thompson, R. T. Brown, and C. R. Dryer. S. S. Gorby was appointed State Geologist in 1889 and served until 1894. He was aided by, Maurice Thompson, M. N. Elrod, A. C. Benedict, E. P. Cubberly, and C. R. Dryer. The productive surveys of W. S. Blatchley began in 1895 and continued for a period of 16 years. Important geological investigations were carried on during the Blatchley period. His earlier staff was composed of C. E. Siebenthal, E. M. Kindle, J. T. Scovel, and J. A. Price, all local geologists, and in addition he had the specialists T. C. Hopkins and G. H. Ashley on the survey. Other geologists contributing to the geology of Indiana before 1900 were C. S. Beechler, V. F. Marsters, John Newsom, Joseph Moore, L. F. Bennett, A. C. Veatch, A. H. Purdue, W. A. McBeth, and Glenn Culbertson. Of the 44 geologists herein mentioned, 34 were residents or natives of Indiana.

Early Hoosier Archaeologists, GLENN A. BLACK, Indiana Historical Society, Angel Mounds.—John Collett, Sylvester S. Gorby, Edward T. Cox, Willis S. Blatchley and Rufus D. Hayman were geologists who took advantage of their intimate contact with the land to make archaeological observations. Many of these observations were made at an early date, and are in their published reports. As a result, those of us who are interested in the prehistory of Indiana have a record of much data that would otherwise have been lost.

A Study of the Indiana Scientists Sketched in American Men of Science, STEPHEN S. VISHER, Indiana University.—This paper is an extension to two hitherto presented before the Academy. (Two years ago, a statistical study of the Indiana scientists sketched in the 1944 edition of American Men of Science; a year ago, a fuller study of the Indiana scientists who have been starred as especially distinguished).

The present paper is an abstract of a study of all the scientists born, college trained or employed in Indiana who were sketched in any one of the seven editions of American Men of Science, 1906-1944. It is based on a card catalog of about 2850 scientists. Of these, nearly a half (1400) were born in Indiana, somewhat more than a half (1550) graduated from a college or university in Indiana, and about 1800 were employed in Indiana. Of those born in Indiana, about a third (463) went elsewhere for their advanced education and nearly two thirds (831) were employed elsewhere. Of those who were trained in Indiana (1807), about a half (945) were natives of the state and about two fifths (862) were employed at least for a time in Indiana.

Of those employed in Indiana, somewhat less than a third were born here, and nearly a half had part or all of the advanced training here. Thus only about two fifths (798) were neither born nor trained here.

These 2850 scientists list themselves, in their sketches in American Men of Science, in more than 97 sciences. For summary purposes they have been here assembled into nine groups. In order of size, these are: chemisty (773), biology (428), the medical sciences (389), engineering (274), mathematics and astronomy (228), physics (220), the agricultural sciences (177), psychology (137), geologists and geographers (132).

The leading two groups, chemists and biologists, lead in each of the three great categories here used (natives, college trained, and employed). The smaller groups displayed irregular variation; for example, fewer agricultural scientists have been employed in Indiana than of geologists and geographers, but fifty percent more agriculturists were trained here than geologists and geographers.

Of those born in Indiana, but neither educated nor employed here, about 45 percent are chemists or biologists (with 99 and 91 of the 425). Four of the other groups each had 30 to 36 persons of this category, while engineers had 46 and the medical group, 60.

Of those educated in Indiana, but neither born nor employed here, chemists led by a wide margin (86 of the 270); biologists, with 54, are second, and engineers, third. Only 8 geologists and geographers came into Indiana for their training and left soon afterwards.

Of those employed in Indiana, but neither born nor trained here, about 30 percent were chemists (225 of 782). Biologists were second (179) and engineers third (89).

Of those born and educated in Indiana but not employed here, the chemists made up nearly one-fourth (125 of 478). Biologists were 112, physicists, 91, while four other groups each had 32 to 38 in this category.

Only 51 of these 2850 scientists were both born and employed in Indiana but not educated here. By contrast, nearly a seventh of the total were educated and employed here (362 of 2850). A third of these are chemists and nearly a fourth are biologists.

Nearly a fifth of the scientists of Indiana were born, educated, and employed in Indiana. Of this group, biologists comprise 155 of the 491, chemists 103, physicists 57 and the other groups 26 to 47.

Thus it appears that approximately a third of the biologists, chemists, physicists, and engineers employed in Indiana were not born or trained here, while fewer than one-fourth of the agriculturists and geologists and geographers are in this category. Conversely, Indiana has been the birthplace and place of training of large numbers of scientists who found employment in other states.

Early Physics in Indiana (to 1900)

R. R. Ramsey, Indiana University

About the only source of information about early Physics is that found in college catalogs. In England one could consult the various publications of the Royal Society, organized in 1660, and later societies. The Philosophical Transactions and the Proceedings of the Royal Society contain many articles pertaining to Physics.

The first meeting of the Royal Society was held at Gersham College. Thus early Physics as well as other branches of science has been associated with colleges since the beginning.

In Indiana we have very little or nothing handed down through learned societies until the founding of the Indiana Academy of Science in 1885. Thus our only source of information is from the early publications of the Indiana Colleges. The College Catalog was the only publication. This, in the early days, may be a sheet of four pages. This contains a list of the Trustees, of the Faculty, with their titles, a list of the students, and a course of study. In a sheet of four pages the information given in the Course of Study is necessarily rather meager.

Here I have made no attempt to consult college catalogs, other than those of Indiana University. So my source is Indiana University catalogs and the Proceedings of the Indiana Academy of Science.

Early Physics, or Natural Philosophy, is somewhat mixed with other sciences, such as Astronomy and Chemistry. In the early catalogs of Indiana University, Chemistry, Natural Philosophy, and Astronomy at times seem to have been given as one course. We find Chemistry, Heat, and Electricity listed as one course. Sometimes it is Chemistry, Acoustics, and Optics. Professors of Natural Philosophy seemed to be those who taught Mathematics, Physics, Chemistry, Astronomy, and perhaps Botany and Zoology. I suspect that some of these professors taught Latin and Greek in order to while away their spare time.

In the earliest catalog I found—1831—the name of Dr. John H. Harney, A.M., Professor of Mathematics and Natural and Mechanical Philosophy and Chemistry. There were three other names in the faculty list. In the list of studies for the junior year we find "Mathematics finished, Mechanics, Astronomy, Physics, Mathematical and Physical Geography." A statement is made that a "chemical and philosophical apparatus has been procured and the foundation of a well selected library has been made." It would be interesting to know just what a chemical and philosophical apparatus was.

The catalog of 1871 has lists of the teaching staff from 1832-1871. John H. Harney, 1831, is not mentioned in the list of Professors of Physical Science. However, the 1831 catalog has Natural Philosophy as one of the many subjects of which he was professor. The list of Professors of Physical Science 1832 to 1867 is as follows:

Ebenezer N. Elliott, A.M., 1832-37; Rev. Theopholis A. Wylie, A.M., 1837-53, 1855-63; Rev. Rovert Milligan, A.M., 1852-53; General Jacob Ammen, A.M., 1854, and Richard Dale Owen, M.D., 1863-67.

It states that Richard Dale Owen was elected Professor of Natural Science in 1867. The catalog of 1870 has Theopholis A. Wylie as Professor of Natural Philosophy, and Richard Dale Owen as Professor of Natural Science.

Thus starting with Harney 1831 as Professor of Natural Philosophy, we have a professor of Natural Philosophy or a professor of Natural Science from the beginning to 1871. Following this date we have Theopholis A. Wylie as Professor of Natural Philosophy or Professor of Physics until 1887, when Wylie is listed as Emeritus Professor of Physics.

In the catalog of 1837-38 where Theopholis Wylie is listed as Professor of Natural Philosophy and Chemistry we find the statement: "A laboratory and lecture room recently has been erected on the campus of the university. It offers to young gentlemen who intend ultimately to devote themselves to the Medical Profession great advantages." The catalog of 1860, where Professor Wylie is now listed as Professor of Natural Philosophy (chemistry is left out of his title), states that "The Chemical lectures and those in Natural Philosophy are illustrated in a series of experiments in the laboratory." About this time or somewhat before, this statement is found: "Additions have lately been made to the apparatus of the university, including a large Ruhmkerf coil, an improved air pump, a syren, and an Electro Magnetic Machine."

In 1885-86 Wylie is listed as Professor of Physics and J. P. Naylor as Associate Professor of Physics. In the 1886-87 catalog Wylie is Emeritus Professor of Physics. Having been Professor of Natural Philosophy from 1837 to 1886—fifty years if '37 and '86 is counted. J. P. Naylor is Acting head of Physics. The next year, 1867, Naylor is made Professor of Physics.

In 1886-87 under Naylor, the course in Physics at Indiana University was:

I Popular Lectures, with Gage as a text.
II Elementary Physics. Anthony and Brackett as text.
III and IV Laboratory Courses.
V Advanced Laboratory Studies, Thesis.

Naylor, a watch maker by trade, a born mechanic, and an industrious personage came at a time when electricity began to be useful and electrical apparatus was scarce and expensive. Naylor made the most of his apparatus. No sandpaper was allowed. The corners and edges had to be square and true. Naylor resigned to go to DePauw University as Professor of Physics in 1891. He told some one that he thought that DePauw has a greater future than Indiana University at that time, and DePauw also had a better ball team.

Associated with Professor Naylor during his last year was A. L. Foley as Instructor. In 1891-92 Benjamin F. Snow is listed as Professor of Physics on leave of absence. A. L. Foley as Associate Professor in charge of the Physics Department.

In 1892-93 Benjamin F. Snow, Professor, with A. L. Foley as Associate Professor. In 1893 Snow resigned to go to the University of Wisconsin as head of Physics. He remained at Wisconsin until he retired.

From 1893-96, Foley was in charge with Charles T. Knipp, Instructor. In 1896-97 Foley was on leave at Cornell. Knipp was in charge and Rolla R. Ramsey was Laboratory Assistant. In 1897-98, Foley was made Professor of Physics, with Knipp Instructor. In 1898-99 Knipp was on leave at Cornell. R. R. Ramsey Instructor.

In 1903 Knipp resigned to go to Illinois University, and R. R. Ramsey came as Assistant Professor.

Thus ends the Indiana University chapter, from 1831 to near 1900. No doubt a very similar chapter could be gleaned from the early catalogs of other Indiana colleges.

For my source of information about Indiana Physics in general I have consulted The Proceedings of the Indiana Academy of Science. The first meeting of the Indiana Academy of Science was at Indianapolis December 29, 1885. 1885 was the last year of Theopholis Wylie's career as active Professor at Indiana University, and the first year for J. P. Naylor. There were no published proceedings of the Academy until 1891.

The first published proceedings gives the programs of the previous meetings. Going through the programs and picking out the titles which seem to pertain to Physics, one finds the following men who gave papers.

As a parenthetic remark it should be said that in the early part of the nineteenth century Physics was mixed up with other branches and listed in general as Natural Philosophy. In the same manner near the end of the nineteenth century as well as in the twentieth century when some Physics had become "useful" we have it mixed up with—or perhaps it would be better to say it has been separated from the "useful." The "useful" has become Engineering. Some of the men whose names appear below were not teaching in Physics Departments. In Purdue University and Rose Polytechnic Institute they were listed as Electrical Engineers or Mechanical Engineers. As, in the twentieth century, we now have Radio Engineers, Acoustical Engineers, and Optical Engineers, we may expect in the near future to hear of Atomic Engineers, as soon as the atom has been put to useful rather than destructive purposes.

In the programs of the first six years 1885-91 of Indiana Academy we find J. P. Naylor giving papers in '85, '98, '90, and '91. Naylor is listed with Greencastle as his post office. However, Naylor did not leave Indiana University for DePauw University until 1891. So there may be some mistakes in my locations of other men. T. C. Mendenhall gave papers in '86, '88, and '90, address given as Washington, D. C.; Thomas Gray, papers in '88, '89, and '90, address Terre Haute; S. Lee Mees, papers in '88, '89, '90, Terre Haute; H. W. Wylie, in '88, paper titled "Refraction Index of Lard and Sorghum," probably at Lafayette at the time; E. G. Walters, '88, Lafayette; A. P. Carman, '88, '90, '91, Lafayette; J. E. Meers, '91, Richmond, Indiana; F. P. Starffer, '91, Logansport; R. A. Smart, '91, Lafayette; Mary Childs Noyes, '91, (?); F. M. Goss, '91, Lafayette; A. Wilmer Duff, '91, Lafayette; W. E. Goldsborough, '91, Lafayette; B. F. Snow, '92, Bloomington; A. L. Foley, '94, Bloomington; W. K. Hatt, '96, (not listed); C. T. Knipp, '96, Blomington; Fred Morley, '96, (?); S. N. Taylor, '96, W. Lafayette; A. L. Foley, '97, Bloomington; M. J. Golden, '99, Lafayette; J. L. Campbell, '99, Crawfordsville; E. S. Johannett, 1900, Terre Haute; Rolla R. Ramsey, 1903, Bloomington; Rolla R. Ramsey and Peter Haseman, 1904, Bloomington.

The above list gives names of men only. Some of these will be recognized as eminent men in other lines than Physics. Some to me are only names. I do not feel that I am qualified to comment on very many. Indiana cannot trace Physics back as far as the date of the beginning of the Royal Society 1660. However, if one considers the state of civilization and settlement of Indiana, the comparison between early Physics in Europe and early Indiana is very favorable.

A Brief History of the Conservation of Natural Resources in Indiana

H. H. MICHAUD, Purdue University

The early geological surveys in Indiana before the Civil War were conducted largely as investigations for exploring the possibility of developing the use of the natural resources like coal, limestone, gas, and oil. An act of the State Legislature, approved February 6, 1837, provided for a geological survey of Indiana. Dr. D. D. Owen was appointed as the first State Geologist and published a report on a "Geological Reconnaissance of the State of Indiana" for the year 1837.

Similar geological studies were continued for several decades by Dr. Owen and later by his brother, Dr. Richard Owen, who in his report for 1859-1860 included an analysis of the soils, a survey of the coal fields, and topographical work of the state.

In 1869, the Forty-sixth General Assembly of the state of Indiana created the office of the State Geologist, to act in connection with and under the control and management of the State Board of Agriculture, for the purpose of collecting information designed to promote the interests of agriculture, arts, manufactures, and minerals. Mr. E. T. Cox was appointed to the first office as State Geologist.

In the introduction to the first annual report of the State Geologist, Mr. Cox says, "Soon after receiving the appointment of State Geologist from his Excellency, Conrad Baker, Governor of Indiana, I proceeded to pack my large and valuable collection of minerals, fossils, shells, and other objects of natural history, also my chemicals and chemical apparatus, etc., etc., preparatory to making my residence in Indianapolis, and with a view of arranging them in the Geological Department of the State House.

"On arriving at the Capitol with this collection, it was soon made manifest that the room set apart for the use of the State Geologist was totally inadequate to hold the natural history specimens and chemical apparatus, and to be used at the same time, as office and laboratory.

"The State Officers, with one accord, decided to have a small addition, suitable for a chemical laboratory, built on the east side of the State House, adjoining the rooms of the Indiana Board of Agriculture.

"Thereupon began investigations of iron smelting and ores and fluxes used in the blast furnaces of Indiana. Other duties of the office included acting as counsellor and informant to people interested in investing capital for manufacturing enterprises in Indiana."

From the first and in the years following there were numerous accounts in the annual reports of the flora and fauna, especially of the timber resources, of the various counties of the state. Much attention was also devoted to the agricultural crop potential of the land.

A few examples are included at this point to emphasize the heavy impact of the early settlers on our natural resources and also the early recognition of the necessity of good farm conservation practices.

The first annual report for the year 1869 in a list of the birds and mammals of Franklin county says, "It is only within the last ten to fifteen years that the red fox has been observed in this county. Previously, none but the gray fox was seen." The wildcat was mentioned as rare, the raccoon abundant, the black bear was last seen about thirty years ago, (1839), although claw marks were still plainly visible on the beech trees. There were no more deer. The Parakeet and Ivory-billed woodpecker had not been seen for many years. The Passenger Pigeon was still found in large numbers although they were regarded as having been constantly reduced in the preceding forty years. The Wood Ibis occasionally visited the White River valley. Such were the original evidences of disappearing wildlife, nearly eighty years ago, caused by the early influence of clearing land for agriculture.

The 1872 Geological Report on Dearborn, Ohio, and Switzerland counties in practical suggestions on farm husbandry recognized the loss of soil fertility. It reads as follows: "The farmer's habits of observation enable him quickly to detect a field of natural fertility that has been worn out. By bad management it has been so changed that it will produce but one-half or one-third the crop that was raised on the virgin soil. The soil may lose its fertility by taking the products off the farm each year, leaving less plant food in the ground for the next crop. Some of the upland has been exhausted by raising corn so that it now is difficult to get grass well set."

Practices of good husbandry recommended (1) Sowing clover and turning under the green crop, (2) Sowing a crop of rye in the fall, clover in the spring, and turning in hogs in September for pasture, (3) Plowing in green manure and pasturing was insufficient so that additional fertilizer was needed, (4) Stable manure and rotten straw was highly recommended, (5) Experiments with lime were encouraged as results of this practice were not well known, (6) Crop rotation, and (7) the use of artificial fertilizers, it was suggested, should be used with caution.

The quite modern question, except for the figures, asked was, "But if a farm nets $10.00 per acre when a profit of $20.00 to $30.00 is within reach, is this not poor management?"

The 1875 report on the agriculture of Jefferson county says, "The potash and phosphates taken up by the crops as food must be returned to the soil, or the land will be impoverished to the amount abstracted from it." Again in 1881, speaking of the soil of Bartholomew county, the author says, "will the farmer husband this heritage or dissipate it by the slovenly methods of working his land and non-rotation of crops? A soil once exhausted, can only be brought back to fertility at great cost, and at the expense of some other locality that must furnish the necessary organic matter, or else wait years for it to be renewed by the slow processes of nature."

The 1876 report includes a record of the "Flora of the Lower Wabash Valley" by Schneck that is worthy of note. The circumference of trees measured three feet above ground were tabulated. The list included:

	Circumference
Pecan	16 feet
Bur Oak	22 feet
Black Walnut	22 feet
Mulberry	10⅓ feet
Sycamore	33⅓ feet
Tulip	25 feet
Cottonwood	22 feet

Of these trees the author made the following comments: "The measurements can only be regarded as those of a remnant of a once extensive, luxuriant and exceedingly massive growth of forest trees. Could they be compared with those that might have been taken fifty to seventy five years ago, they would doubtless be far surpassed. One cannot suppress a sigh of regret over the many prostrate and decaying bodies of those grand old monarchs of the forest, whose venerable lives have been sacrificed, when in their fullest manhood and grandeur, by the indefatiguable frontiersman, for a hive of honeybees or a raccoon that has sought refuge and a home in the hollows of their bodies or massive limbs.

While the wasteful destruction of timber has been great, yet it can in no way be compared with the amount annually taken from the woods for useful purposes. Scattered through the country, and at almost every bend in the river, will be found saw mills; some of which have been almost daily doing the work of destruction for the last fifty years. And of late, the more ravenous, portable saw mills have gone to the more inaccessible localities, until there is scarcely to be found a spot from which the best timber has not been culled. Judging from the past, it is safe to say: the time is not distant when there will scarcely be left a sample of these monuments of centuries growth."

Such were the ravages of the land that were well known and obviously were the concern of the conservationists in the last half of the nineteenth century in Indiana.

For many years the office of the State Geologist functioned primarily as the only agency of the state government concerned with natural resources. In the early part of the present century, numerous laws appeared for the protection of resources and the separate offices of Entomologist, the State Board of Forestry, the State Park Commission, and Superintendent of Fisheries and Game were added.

In 1919 the state legislature established the present Indiana Department of Conservation. The law provided a non-partisan Conservation Commission of four members, a Conservation Director responsible to the Commission and Directors for each of the Divisions of the Department. Richard Lieber, as first director, served until 1933. The original state owned lands totalled 2,766.11 acres including Clark County

State Forest; Riverside, Tri-lakes and Wawasee Fish Hatcheries; Turkey Run and McCormick's Creek State Parks. By comparison, state owned properties today include sixteen State Parks, sixteen State Forests, four State Game Reserves, fourteen State Memorials, and nine State Fish Hatcheries.

The aim of the Department of Conservation as expressed in a publication in 1919 entitled, "The Why and Wherefore of Conservation in Indiana" was "to make every Hoosier a conservationst, who believes in the state and the laws which are in force to conserve its natural resources for the benefit, education and recreation of all Hoosiers now and to come."

Some important strides in connection with the Indiana Department of Conservation have been made since 1919. The Forest Land Classification Act of 1921 has become one of the state's most potent vehicles for better forest protection, management and utilization on privately owned lands. Lands thus classified are designated by the state forester as eligible for the special assessment of only one dollar evaluation per acre. This tax savings inducement plus a more intelligent interest in forest conservation by 1946 was responsible for 120,000 acres of classified woods by twenty-two hundred private owners.

However, there are still approximately 800,000 acres of the state in need of reforestation. This is land unsuitable for farming and must be in trees to be productive. The annual nursery stock of about 4,500,000 trees is inadequate to supply the demand for foresting both public and private land. Present nurseries should be developed to provide 15,000,000 trees annually and the magnitude of the task is emphasized by the fact that fifty years would be required to reforest the land even at this annual production figure.

Wildlife research is made possible in Indiana, under the Pittman-Robertson Act (1937) through the cooperation of the United States Fish and Wildlife Service and the Indiana Division of Fish and Game. The act provides the states with aid in wildlife restoration projects, from funds obtained through a ten percent excise tax on the sale of sporting arms and ammunition. Seventy five percent of the funds used by these projects in the state (allocated to the states on the basis of the number of hunting licenses issued), are provided by the Federal Government and twenty five percent by the state.

Indiana has participated in this program since December 1, 1940. Provided that, in each case, the primary purpose is wildlife restoration, the funds may be used for three kinds of projects: (1) purchase of land, (2) development of land, and (3) research studies.

In Indiana, Pittman-Robertson funds have been used to help purchase the Hovey Lake State Game Preserve and additional acreage at the Jasper-Pulaski State Game Preserve. White-tailed deer have been bought for release in southern Indiana. Wildlife habitat areas on private lands have been developed and a continuous program of research has been in progress since 1940. Progress reports of this work are issued quarterly.

The County Forest Law, created to authorize county commissioners to acquire lands to establish county forests, the work of the Indiana Stream Pollution Control Board in cooperation with the State Board of Health, the Indiana Flood Control Commission and the excellent investigations of the more recent Division of Water Resources of the Department of Conservation should be mentioned as evidence of the growing demand on the part of the people for the conservation of the state's natural resources.

Not all of the influence for improved conservation practices have emanated from the Department of Conservation. During the thirties, the Land Use Planning Committees, composed of local farmers in every county of the state, were a potent force in developing the need for state-wide land conservation. These committees evaluated the farm land on the basis of the best use to which the farms of the county should be put and made recommendations as to the kind of crops that could be grown most advantageously.

The Soil Conservation Districts Law was passed by the Indiana legislature in 1937, amended in 1941 and 1945. Its purpose is expressed in the Declaration of Policy: "It is hereby declared to be the policy of the general assembly to provide for the conservation of the soil and the soil resources of this state, and for the control and prevention of soil erosion, and thereby preserve natural resources, control floods, prevent impairment of dams and reservoirs, assist in maintaining the navigability of rivers and harbors, preserve wildlife, protect the tax base, protect public lands and protect and promote the health, safety and general welfare of the people of the state."

Twenty five or more landowners (a large number is preferred) of a given area petition the State Soil Conservation Committee asking that a district be organized. A district may be county-wide, part of a county, or parts of more than one county. Most of them are organized on a county-wide basis.

After the State Committee examines and approves the petition, it conducts a public hearing, giving opportunity for all interested parties to be heard. If the hearing shows that a district is desirable, the boundaries are established and a referendum is held. Landowners may vote "for" or "against" the creation of a district. If sixty percent or more vote in favor, the State Committee may declare the district legally created.

There are now forty-one soil conservation districts in Indiana representing over seven thousand individual farm conservation plans, or about eight hundred and fifty thousand acres. These farms are exercising good land use through corrective farm practices like (1) contouring, (2) strip cropping, (3) terracing, (4) vegetated waterways, (5) improved crop rotations, (6) cover crops, (7) pasture improvement, (8) tree planting, (9) woodland management and, (10) use of farm ponds.

Considerable progress has been made in scientific research and public education. The Lake and Stream Studies conducted by Indiana University and the research in forestry and wildlife by Purdue University in cooperation with the State Department of Conservation have made possible many improvements in conservation practices. The results of research in good soils management, agronomy, and forestry and wildlife management have been made available to the farmer through the Agricultural Extension Service. Education in conservation for rural youth has been stimulated through the 4H Club projects and the annual 4H Club Conservation Camp at Versailles State Park.

A special program in conservation education for public schools was initiated in 1945. Through the cooperation of the State Office of Public Instruction, the Indiana Department of Conservation and Purdue University the program for the schools has included: (1) bulletins about soils, water, plants and wildlife conservation, (2) counselling with teachers and administrators and (3) a six weeks field course in conservation for teachers at Versailles State Park.

Several private industries and many non-profit organizations like the Women's Garden Clubs, Izaak Walton League Chapters and others have taken an active part in promoting this work in the schools and in giving financial support for local teachers to attend the summer camp.

Reference to past proceedings of the Indiana Academy of Science reveals that numerous papers have been devoted to native resources and their conservation, especially in geography, geology, botany, and zoology. The Academy, in some states, has seen fit to schedule a separate section on resource use. The Indiana Academy has not yet pooled its conservation interests in this manner, but as an effective force in molding scientific pursuit and thinking, such a move might be worthy of consideration.

Historical Landmarks of Chemotherapy

C. A. Behrens, Purdue University

The earliest history of medicine is that of ancient Egypt and reveals the fact that these primitive people searched the vegetable, animal and mineral kingdoms for substances which would be efficacious against disease.

During the 3000 year Pharaonic Dynasties, ending in 340 B. C., and the Chou Dynasty, 1130-250 B. C., chemicals were employed to combat disease. In the latter period mercurial ointments were used in the treatment of syphilis.

In the early middle ages Paracelsus (1493-1541) used lead, copper, mercury, and even derivatives of gold. Chemotherapy probably had its beginning with the work of Paracelsus in 1526. All of these substances were employed wholly in an empirical manner. These hit and miss methods undoubtedly met with success in some instances. Mercury was used by the Arabians for syphilis and they introduced it into Europe in the 16th century.

The Peruvian Indians of the 17th century used cinchona bark, a source of quinine, against remittent fever, malaria. Also, the Brazilians, according to the writings of Willem Piso (1611-1678), a Dutch physician, who visited South America in 1636-44, recognized the value of ipecacuanha root, ipecac, the active ingredient being emetin, for tropical amebic dysentery. Everything under the sun was tried sooner or later with the idea of changing the reaction of the blood in order to make it unfit for the parasite to develop in.

Discovery of antisera for tetanus and diphtheria in 1894 sidetracked this work. This was renewed in a different spirit in 1900 when protozoal parasites became important. Since that time the laboratory has accomplished wonders.

Real experimental chemotherapy began in 1904 with the significant experiments of Dr. Paul Ehrlich and his collaborators Ulenhuth and Shiga. Reported cures of mice suffering from the otherwise fatal trypanosomal disease of human sleeping sickness by a single injection of trypan red were announced. This dye and trypan blue were used in Leishmaniasis. Ehrlich visited this country in 1904. Ehrlich's aim was "Therapie Sterilisans Magna," to kill everything at once. He hoped to destroy the invading organism in one or two days by a single dose of the drug. The action was compared to a bullet going through the body and destroying the parasite but leaving the cells of the host unharmed. The goal was to find a chemical which had greater affinity for the parasite, that is, parasitotropic, than for the tissues of the host or organotropic.

Arsenic was used early in an empirical way. In 1850 David Livingston, a missionary to South Africa, administered arsenic to animals sick with tick-fever. There was a temporary improvement followed by decline, reappearance of the parasite and finally death ensued. In India, Lingard used arsenic in surra, a trypanosomal disease (Trypanosoma evansi) of horses, cattle, camels and elephants. Again there was usually death after temporary improvement. In 1903 Laveran, discoverer of the protozoan causing malaria in 1880, injected Fowler's solution (potassium arsenate) and noted the same results.

The parasites that survive the treatment become accustomed to the chemical and are no longer affected by it. Such organisms are known as "fast," "chemofast," "arsenic fast." Consequently, one must guard against such fastness in the treatment of disease. A rotation of different kinds of chemicals is used such as compounds containing arsenic, others bismuth and still others containing antimony.

Some of these synthesized preparations were effective in some diseases but gave no results with others. "Trypan blue" proved to be valuable in the treatment of parasites that cause the general disease known as piroplasmosis affecting mainly cattle but it is very disappointing in the treatment of trypanosomiasis.

Shortly after Laveran's report, Thomas (1905), an Englishman, showed that a proprietory organic arsenic preparation known as "atoxyl" was effective against trypanosomal infections. This announcement led to an expedition headed by Robert Koch to tropical East Africa for the purpose of trying "atoxyl" on natives suffering from sleeping sickness (trypanosoma gambiense). "Atoxyl" had marked effect upon the parasite but it was also very toxic to the host and consequently could not be used.

In 1905 Schandinn and Hoffmann announced the discovery of the causative organism of human syphilis (Treponema pallidum). All attempts to produce curative antisera failed. Ehrlich's trial experiments of the effect of arsenic compounds upon this treponema and relapsing fever spirochetes seemed promising. Through long tedious processes of elimination more and more effective arsenicals were synthesized. The 606th preparation seemed to have the properties of an effective agent. Experiments with syphilis infected rabbits gave startling results, the treponema was apparently destroyed, lesions healed and cure resulted.

Tests on syphilitic humans (luetics) were confirmed by animals. In 1909, "arsphenamine," its official name, was given to the medical profession. This was an epoch making discovery against a disease which for centuries was a curse to mankind. Metchinkoff and Roux in 1903 showed that calomel ointment when applied one or two hours after cutaneous inoculation with this treponema prevented infection. Arsenicals of this nature are also most effective for yaws, bejel, pinta and relapsing fevers.

Other developments such as the syntheses of trypanocides followed and in 1921 the Rockefeller Institute for Medical Research produced "tryparsamide." Its effectiveness against human sleeping sickness was established during an expedition to the Belgian Congo. The Germans synthesized "Bayer 205" or "germanin" in 1920. Three years later the

French prepared two very effective trypanocides, "Fourneau 270" or "arsanine" and "Fourneau 309" or "moranyl." The former is comparable to "tryparsamide" while the latter is similar to "Bayer 205."

Another important advance in chemotherapy was the discovery in 1921 of the value of bismuth compounds. These synthesized preparations greatly surpassed mercury as an effective antisyphilitic remedy. Such preparations are also used in combination with "arsphenamine."

Still another group of chemicals containing antimony have been synthesized. These antimonials are especially effective against the various types of Leishmaniasis. As early as 1913 Vianna employed antimony tartrate in these infections.

There was much interest manifested in the development of new antimalarials and in 1926 "plasmochin" was synthesized. It is claimed that "plasmochin" is effective against all the different types of malaria including the pernicious form which does not respond to quinine.

Another effective antimalarial is "atabrin" which is less toxic than either quinine or "plasmochin." This complex chemical was first synthesized by Mauss and Mietsch in 1933. This yellow, bitter tasting, fluorescening powder destroys the schizonts while "plasmochin" is a gametocide.

The exact synthesis of the alkaloid quinine was accomplished by Robert B. Woodard, Harvard, and William E. Doering, Columbia, in 1944.

Bacterial Chemotherapy

The greatest triumphs in chemotherapy were against protozoal and spirochetal infections. Since most of the infectious diseases of man are caused by bacteria, it was of prime importance to discover specific chemicals for bacterial diseases.

It was at first thought that bacteria were too simple in structure to lend themselves to treatment by chemicals which in turn would not be toxic to the host. Koch in 1881 failed at bacterial chemotherapy in anthrax of guinea-pigs. Many attempts were made on various laboratory animals with practically no success until 1911 when Morganroth and Levy reported a cure of mice suffering from pneumonia following injections of ethylhydrocuprein. However, it possessed no clinical value because the curative dose was too near the lethal one. The discovery of the group of "sulfonamide" chemicals as therapeutics completely altered the situation.

The historical landmarks of bacterial chemotherapy briefly are as follows: In 1908 P. Gelmo, a student at the University of Vienna, synthesized "sulfanilamide" from coal tar for his Ph. D. degree. His work was forgotten for over twenty years but was again brought to light in 1930 when Fritz Mietzsch and Joseph Klarer, who had just completed the synthesis of "atabrin," began their experiments on bacterial chemotherapy. For some reason or other they decided to use "sulfanilamide," Gelmo's synthesis, as a starting point. In 1933 Dr. Forrester saved the life of a ten-months-old boy who was dying from staphylococcus septicemia following injections of "streptozon" which was thought to be effective against streptococci. It's name was then changed to "prontosil." This was the first evidence that Mietzsch and Klarer had succeeded. They patented this azo dye in 1932. Domagk in 1935 cured mice and rabbits suffering from streptococcal infections with "prontosil." His published results awoke the world to the fact that a new chemical against bacterial diseases was at hand. Domagk's work was shortly, thereafter, confirmed by Levaditi and Vaisman in France and Colebrook and Kenny in England. Next in 1936 Jacques, Trefouels, Nitti, Dovet of the Pasteur Institute in France and Buttle, Gray and Stephenson in England showed that the simple "sulfanilamide" fraction, which it will be called was prepared by Gelmo in 1908, of the complex "prontosil" was alone the effective agent against bacterial infections, and also, was much less toxic. Thus, the patents on the azo dye "protosil" were valueless.

Ehrlich's purpose of chemotherapy was to destroy all the invading organisms by a single injection of the chemical. However, satisfactory results in the use of these chemicals depends upon two things: Effective blood concentration and a sufficient duration of this concentration. That is, the dose is not the amount of the chemical given but rather should be in terms of blood concentration and duration of time.

Many thousands of chemicals of the sulfonamide type have been tested in mice but only a relatively few, sulfanilamide, sulfadiazine, sulfapyridine, sulfathiazole, sulfaguanidine, and succinylsulfathiazole are employed against diseases of man.

Antibiotics as Therapeutic Agents

Pasteur in 1877 observed that, when animals, susceptible to anthrax, were injected with the bacillus contaminated with certain organisms, infection often failed. Later in 1889 it was shown that sterilized cultures of the bacillus of green pus, Pseudomonas pyocyaneus, and culture filtrates, pyocyanase, were effective when injected into rabbits suffering from anthrax. The action of pyocyanase, however, was not substantiated.

In 1929 Professor Alexander Fleming at St. Mary's Hospital, London, discovered "penicillin" a most effective antibiotic against bacterial infections. Penicillin was obtained from a specific kind of a common green mold, *Penicillium notatum.*

In 1936 Professor H. W. Florey and associates at Oxford University, England, began to investigate the action of "penicillin" and in 1940 isolated it in the form of a brown powder.

Dubos of the Rockefeller Institute in 1939 discovered the antibiotic "gramicidin." Waksman in 1944 gave us "streptomycin" and Meleney in 1947 "bacitracin." Antibiotic substances are produced by actinomycetes, algae, bacteria, fungi and green plants. Millions of experiments are being conducted in order to discover more effective antibiotics. One of the latest to be announced is "circulin" by Drs. Murray and Tetrault of Purdue University. It's effectiveness is especially against so-called Gram negative microorganisms.

And so, as the use of chemicals against disease goes on, this quotation from Sophocles, made about 500 years B. C. in his drama, "Antigone," becomes more and more realistic, "Only against death shall he call for aid in vain, but from the baffling maladies he hath devised escape."

Early Studies on Protoplasm

Raymond E. Girton, Purdue University

Introduction

The active living substance of both plant and animal cells, which we now call protoplasm, has interested and baffled man since its discovery three centuries ago. Its importance is recognized in such phrases as the statement that protoplasm is "the physical basis of life" and in present-day definitions which point out that protoplasm is "the essential material of which living creatures are composed."

Current knowledge indicates that every living cell contains a small quantity of protoplasm. The bulk of this protoplasm is usually cytoplasm, which in plant cells, abuts upon the surrounding cell wall. This cytoplasm is believed to function under the control of a directing nucleus which is generally confined within the cell unit. Here the nucleus lies submerged in, or surrounded by, the cytoplasm.

Most cells are vacuolated, that is to say they contain one or more vacuoles, or resevoirs, which are filled with water and various solutes. Mature plant cells, in contrast to those of animals, usually contain one large vacuole which occupies the bulk of the cell. In these cells, the cytoplasm is confined to a thin layer along the wall, plus occasional strands, which may stretch across the vacuole. The nucleus is found either in the sytoplasm adjacent to the wall, or suspended in the vacuole by means of strands of cytoplasm and enclosed in a thin envelope of the same material.

The Pre-protoplasmic Era

In 1665, the English natural philosopher, Robert Hooke, published his "Micrographia" in which he described numerous observations made with a microscope of his own design. Hooke who had broad interests in the field of science, was a mathematician, a physicist, an inventor, a surveyor, an architect, and a doctor of medicine. He served as curator for the Royal Society for over forty years. While not a biologist by training or profession, it was his good fortune to be the first to publicize the cellular structure of plant tissues.

Although his first recorded observations were made upon the structure of non-living cork, Hooke also reports that further observations were made upon thin sections of living plant tissues. These objects he likewise found to possess cellular structure. This was as far as Hooke's curiosity led him, for he turned his attention to other things and left the careful study of plant structure to workers of the next decade.

From the English Hooke we pass to Leeuwenhoek of Holland, a contemporary who outlived Hooke by twenty years. Leeuwenhoek was a master builder of microscopes of original design. Although his were simple microscopes, each containing but a single lens, yet his skillful grinding and choice of materials were such that he obtained magnifications of as high as 270 diameters.

With the aid of these microscopes, Leeuwenhoek made a very great many observations and discoveries of tremendous importance to biology. For example he observed and accurately described one of the smallest of man's cells, the red blood corpuscle. He also observed the cells of yeast plants, the eggs of weevils and of flies, and the spermatozoa of dogs and man. His superior lenses and keen eyesight enabled him to discover the existence of protozoa and finally, to climax his previous work, to see and describe bacteria for the first time. This he did in 1683 at the age of sixty years.

It remained, however, for the Italian physician Malpighi and his English medical contemporary Grew to use the microscope as a tool for the patient, minute study of higher forms of living organisms. Both Malpighi (1679) and Grew (1682) published independently an "Anatomy of Plants" in which the structures of organs and tissues were painstakingly detailed in terms of the tiny cells of which they are built. While the work of Malpighi and Grew stressed the different tissues which were constituent parts of the organisms they studied, yet the smallest unit of structure, the cell, is shown in their drawings in easily recognizable form.

"Sarcode"

As far as known, neither Hooke nor the keen-sighted Leeuwenhoek, nor even the students of plant anatomy-Malphigi and Grew-ever clearly saw living protoplasm. If they did, no importance was apparently attached to such an observation. This can be explained on the grounds that, owing to imperfections in the microscopes of the seventeenth century, accurate observations upon the internal structure of living cells were out of the question. It remained, therefore, to the workers of the 18th century to begin this phase of cellular investigation. According to some authors, it was the Italian "cytologist" Corti, who in 1772 early observed and reported the existence of the slimy substance present in living cells. That Corti followed up this observation is shown by the fact that he discovered currents existing within the cell. This flowing movement we now speak of as protoplasmic streaming. Corti's observation upon protoplasmic streaming was later substantiated by Treviranus, a German botanist and professor at Bonn.

But progress in the field was extremely slow since it waited upon the further development of the microscope. This did not come until early in the nineteenth century, when microscopes with achromatic lenses began to appear in the laboratories of biological institutions. Thus it happened that the eighteenth century was, on the whole, relatively fruitless in the production of new knowledge of the cell.

With the improved microscopes which were put into use during the first half of the nineteenth century, much light was thrown upon the internal structure of cells. The name of Felix Dujardin (1801-1860) stands out among those who contributed most to this new knowledge. Although trained in art and engineering, Dujardin early developed into one of the leading French biologists. In 1835 he published a paper which, according to a modern authority (Seifriz), contains an accurate description of protoplasm that has not been greatly improved upon to this day. This paper was one of a series "Investigations on the lower organisms" and was entitled "On the supposed stomachs of Infusoria and on a substance called 'Sarcode'." A translation of his description is as follows: "Thus I propose to name that which some other observers have called a living jelly, that glutinous, transparent substance, insoluble in water, contracting in globular masses, adhering to the dissecting needles, and allowing itself to be drawn out like mucus; finally, occurring in all lower animals interposed, on the other structural elements."

Dujardin called attention to the ability of "sarcode" droplets, which were caused to emerge from a protozoan parasite of the earthworm, to produce film formation around the droplets, although this was known to occur only in certain cases.

In a later work (1841) the same author pointed out another property of "sarcode," namely that of forming vacuoles. He says: "But the strangest property of sarcode is the spontaneous production, within its mass, of vacuoles or small spherical cavities." This property of vacuolization Dujardin pointed out, distinguished protoplasm from gelatin, mucus, or albumin and was observed to take place in protozoa following injury.

A contemporary of Dujardin was Dutrochet, the discover of osmosis. This worker, 1837, published a note in Comptus Rendus concerning the effect of temperature, mechanical irritation, salts, acids, alkali, narcotics, and alcohol upon protoplasmic streaming in the alga Chara. He found that streaming took place slowly, even at temperatures as low as melting ice, but increased rapidly with a rise in temperature. Dutrochet also stated that mechanical pressure, when exerted on a plant cell can cause the cessation of protoplasmic streaming.

Another contributor to our knowledge of the cell is the Scottish botanist Robert Brown. Brown, who is the discover of the random motion of particles which bears his name, published in 1831 his discovery of the nucleus or "areola" as he also called it. This important protoplasmic structure he discovered in the epidermis of members of the orchid family, and later demonstrated it in a great number of other plant cells.

Protoplasm

We owe the term "protoplasm" to the Czech scientist Purkinje. This term was derived from the Greek "protos" meaning first and "plasma" meaning form. As used by Purkinje, the term was applied to the formative material of animal eggs and embryos, and was introduced in 1839.

In 1864, there appeared one of a long list of important papers from the pen of the German scientist von Mohl. Von Mohl began his career as a doctor of medicine, then he became professor of physiology, and finally professor of botany. Additional traits include those of a modest and reserved man of science who was able to observe and evaluate known facts in a careful and accurate manner.

In his paper Von Mohl applied the term "protoplasm" to the living substance in plant cells and showed that the "sarcode" of animal cells and the protoplasm of plant cells are essentially the same. Von Mohl described protoplasm in a paper entitled "On the fluid movement in the interior of cells" as "never a clear watery cell fluid but a viscous stringy mass."

Further properties of protoplasm were recorded by Carl Nägeli, a Swiss botanist contemporary with Von Mohl. Nägeli verified the membrane formation taking place at the surfaces of exuded drops of protoplasm. He observed the formation of protoplasmic strands in plasmolyzed Spirogyra cells. These strands, when cut, contracted and pulled back into the main mass of protoplasm. Nägeli, also studied the influence of temperature on protoplasmic streaming, the formation of vacuoles in degenerating plant protoplasm, and the killing of algal cells by dilute solutions of copper and mercury salts.

Before going on to the "protoplasm doctrine" of Max Schultze, let us "turn back the clock" some twenty years and touch upon the cell-theory concept. In 1838, Matthais Jacob Schleiden published an essay entitled "Contribution to Phytogenesis" which forms the first installment of what is now known as the "cell theory." Schleiden was the son of a Hamburg physician and studied jurisprudence, then became a doctor of law, and later a barrister in his home town. At this point in his career, matters took a strange turn. Proving to be unsuccessful at law, Schleiden became despondent and shot himself in the head. In this, he was also unsuccessful, and upon recovery resolved to devote his life to natural science. This he did and thereby gained lasting fame.

In discussing the question of how cells arise, Schleiden emphasized the importance in cell division of the recently discovered nucleus and uncovered the fact that the embryo arises from a single cell. He stressed the cell as an independent unit, presenting, at the same time, the plant as a community of cells.

These concepts applied to plants by Schleiden were extended the following year to animals by the German zoologist, anatomist, and discover of pepsin, Theodor Schwann. He states: "The elementary parts of all tissues are formed of cells in an analogous, though very diversified manner, so that it may be stated that there is one universal principle of development for the elementary parts of organisms, however different they may be, and that this principle is the formation of cells." The importance of these conclusions is pointed out by J. A. Thomson in his book "The Great Biologist." He says "To see many things as one, is one of the ends of science, and the cell-theory gave a new unity to the whole range of animate nature."

While Schleiden and Schwann have usually been given the credit for originating and publicizing the "cell theory," earlier work on this subject should not be ignored. According to Raber, Dutrochet had previously (1824) "(1) established the anatomical individuality of cells, (2) described the universal cellular structure of living plant and animal tissues, and (3) stressed the importance of the cell as the physiological unit of the organism."

In spite of the importance of the views presented by the proponents of the cell theory, their concepts were restricted too much to walls or other cell boundaries. Less attention was given to the living content of the cells and its importance in the physiology of living things. This misconception was corrected by Max Schultze in a short essay entitled "On muscle bodies and what one calls a cell" which appeared in 1861. Schultze had devoted himself to the extensive study of microscopic subjects including single celled animals, leuconsites, and nerve and muscle tissues. From these studies he became convinced that the most essential thing in a cell is not, as his predecessors had stated "a vesicle surrounded by a membrane, with a nucleus and fluid contents," but a mass of protoplasm with a nucleus. Thus to Schultze, the word "cell" becomes, illogically perhaps, the vital "element" represented by the nucleus and accompanying protoplasm. The cell envelope, be it wall or membrane, assumes when present a role of lesser importance. This is in keeping with our modern conception of the life and the component parts of the cell.

Conclusion

We have attempted to trace the development of the concept of structural and functional unity of living organisms from early beginnings up to a climatic statement which gives Schultze's viewpoint of nearly 90 years ago, but which even now represents sound physiological views. In other words, we still hold (to quote Raber) "that the important physiological and morphological unit of all organized life is the nucleated mass of protoplasm."

This does not then mean, of course, that no advancement has been made in subsequent study. Microscopes of greater power and refinement, improved techniques in handling the experimental material, and new knowledge in the fields of colloid chemistry and related sciences have all contributed to aid in man's study of protoplasm. At the same time, the protoplasmic system appears to be so complex, the organization so intricate, and the equilibra so sensitive that a complete understanding of the stuff which we all call protoplasm is not by any means "just around the corner."

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Starred Scientists Born or Trained in Indiana

By STEPHEN S. VISHER, Indiana University

Indiana was the state of birth of 81 starred scientists and the state in which 80 received their collegiate training. These Indiana scientists are about 3.6 percent of all the starred scientists who were born in the United States or received their college training here. They were starred in one or more of the seven editions of "American Men of Science" as especially distinguished in research. The voting was by secret ballot of the leaders in their science. Twenty-eight were starred in the first edition (1906), 11 to 13 in the second (1910), third (1921), and seventh (1944) editions, and 4, 5, or 8 in the other editions.

As part of an effort to learn more about what conditions are conducive to high achievement, the published data on the places of birth and of training of the starred scientists have been studied in considerable detail. In addition, a comprehensive questionnaire was sent in November, 1946, to those living, asking, among other questions, what influences they considered to have been most significant in their own case.

The present article is an abstract of some of the data on the scientists who were born in Indiana or who received their college degree there.

Yield in Proportion to Population

Indiana is exceeded in yield of starred scientists per million of population at their average date of birth by the New England States, the other East North Central States, by half of the West North Central States, and by New York, New Jersey, Delaware, Maryland and Wyoming. Indiana exceeds the remaining states, most of them by a wide margin. For example, Indiana's total yield per million of population is more than 10 times that of Arkansas, Mississippi, or Oklahoma and more than 5 times that of Alabama, Georgia, Louisiana or New Mexico. It was more than 3 times that of North Carolina, West Virginia, Kentucky, Tennessee, Florida or North Dakota. It was more than twice that of South Carolina, Virginia, Colorado, Montana, Utah or Oregon.

In the yield of *botanists*, Indiana was surpassed only by 8 states (Connecticut, Massachusetts, Vermont, New York, Illinois, Michigan, Wisconsin, and Nebraska). In the yield of *zoologists*, Indiana was surpassed by only 10 states (New England, except R. I., New York, Kansas, Minnesota, Maryland). In the yield of *psychologists*, Indiana was surpassed only by 8 states (New England, Utah and Wyoming). For *astronomers*, Indiana was surpassed by 12 states (New England, Ohio, Illinois, Michigan, Minnesota, Colorado and California). As to *anatomists*, Indiana was surpassed by 14 states; as to *anthropologists*, by 4 states; as to *chemists*, by 15 states; as to *geologists*, by 17 states;

as to *mathematicians*, by 16 states; as to *pathologists*, by 12 states; as to *physicists*, by 25 states; and as to *physiologists*, by 12 states. Thus Indiana's rank among the states was lowest as to physicists and relatively low as to geologists, chemists, mathematicians.

Table 1 gives the number of these scientists born in Indiana by decade of birth and by science. It reveals that half of the total were born in the 20 years 1860-1879, 30 were born since 1880, none since 1904. The yield of starred scientists per million of population was about 11 for the 1870's, 10 for the 1860's, 6 for the 1880's and somewhat more than 3 per million for the 1890's and 1900's. The causes for these changes in productivity are significant, and merit discussion.

Table 1 also shows that nearly one-fourth, 19, were starred in zoology, while 12 were starred in botany, 11 in chemistry and 6 or 7 each in geology, physics or psychology. Each of the 12 sciences in which starring has been done is represented by 2 or more Hoosiers. The relatively large numbers starred in zoology reflects the influence of David Starr Jordan. Several of the botanists were students of John Merle Coulter.

TABLE 1. Native Indiana Starred Scientists
Number born by science and decade of birth

Born . . . . . before 1860		1860's	1870's	1880's	1890's	1900's	1910's	Total
Anatomy	0	0	1	0	1	0	0	2
Anthropology	0	1	1	0	0	0	0	2
Astronomy	2	0	1	2	0	0	0	5
Botany	1	5	3	2	1	0	0	12
Chemistry	2	0	2	1	3	3	0	11
Geology	1	3	1	0	0	1	0	6
Mathematics	0	2	2	0	0	0	0	4
Pathology	1	1	0	1	0	1	0	4
Physics	1	2	0	0	2	2	0	7
Physiology	0	1	1	1	0	0	0	3
Psychology	0	3	1	1	1	0	0	6
Zoology	3	3	7	5	0	1	0	19
Totals	11	21	20	13	8	8	0	81
Population Mid-Year Millions	1.2	1.5	1.8	2.1	2.35	2.6		
Yield per Million	9.1	10.0	11.0	6.2	3.4	3.1	0	

Areal Contrasts in Yield of Scientists

List 1 gives by science the names of the starred scientits born in Indiana, with the year and place of their birth, and list 7 presents the birth places by counties. When these birth places are mapped, it is seen that just half of the counties yielded no starred scientists, and a quarter of them yielded only one each. By contrast, Marion County yielded 5, Switzerland, Johnson and Wayne counties each 4, and Jefferson, Union, Hancock, Allen and Vigo 3 each. The yield by quarters of the State's population at the median date of the birth of these 81 scientists (1875) is as follows: the southeast quarter was the birthplace of 29 scientists, giving a yield of 14.5 per 100,000 of population. The northeast quarter yielded 23, or 11.5 per 100,000 population. The southwest yielded 19 or 9.5 per 100,000. The northwest yielded 11, or 5.5 per 100,000. Thus the southeast quarter did nearly three times as well as the equally populous northwest, and the northeast fully twice as well. The eastern half of the state's population yielded 63.5% of the total number, the southern half yielded 58.5%.

The unglaciated part of the State yielded 8 starred scientists, or at a rate of 4.8 per 100,000 of population. The relatively prosperous lower Wabash Valley Lowland of the southwestern part of the State, south of Terre Haute, yielded only one starred scientist. These 9 southwestern counties yielded starred scientists at the rate of one per 220,000 people. Fifteen northwestern counties having a combined population of 250,000 people yielded none. Two of these northwestern counties contain Wabash College and Purdue University. Why should 15 counties east and southeast of Marion County having a combined population of 284,000 people yield 30 starred scientists or one per 9,500 people while a similar number of counties in the northwest having as many people yielded none?

Theories as to Regional Contrasts in Yield

Seven theories as to the yield of notables are:

1. That leaders come from especially prosperous areas. This certainly is not true for all of Indiana. Crawford and Switzerland counties, two of the poorest in the State, yielded at the rate of 1 scientist per 4,200 people, while Benton, Howard, Rush, Blackford, Knox and many other rich counties with a combined population of much more than 200,000 people yielded not one starred scientist.

2. Another theory is that notable leaders come largely from areas which are educationally favored. In Indiana, for example, the counties containing Earlham and Franklin colleges and DePauw and Indiana universities yielded 10 starred scientists, one-eighth of the total number, although at the average date of birth of the scientists these counties contained only 95,000 people, or somewhat less than one-twentieth of the state's population. But on the other hand, 5 of the 6 counties which had the highest yield of starred scientists in proportion to population lacked colleges. These especially productive counties were Union,

Switzerland, Jefferson, Hancock, and Parke, with a total yield of 13 starred scientists from a population of 82,000 people, or an average of one scientist for 6,300 people. (Union and Switzerland counties did twice as well as this average). These 5 counties yielded starred scientists at about 50 percent higher rate than did the best 4 counties with colleges.

3. A third theory to explain the regional contrasts in yield of outstanding leaders is that they come from the culturally more advanced areas, not from frontiers. The Indiana data lends some support to this theory, as the southeastern part of the State was the first to be well-peopled, while the northwest was settled latest. However the inadequacy of this explanation is indicated by the fact that several parts of the state settled early yielded no starred scientist; an example is the southwestern part, Vincennes and Washington south to the Ohio River. Crawfordsville was another early cultural center which has yielded no starred scientists, although several have graduated from Wabash College. And Tippecanoe County, containing Purdue, has yielded none.

4. A fourth theory is that the distribution is erratic, a matter of chance. This theory is disproved by many data. The more the subject is studied, the more evidence is disclosed that "it is not mere chance."

5. A fifth theory is that wherever economic and cultural conditions are at least fairly favorable, the areal differences in yield of notables correlates with contrasts in the quality of segments of the population. In Indiana, a considerable number of the starred scientists were descendents of persons who left Germany in 1848 or soon thereafter, partly because they sought greater freedom from the oppression then imposed. Several other Indiana-born scientists were the children of Quakers or of Scotch Presbyterians who had come to Indiana from the Carolinas before the Civil War partly because they disapproved of slavery. The Quaker group, which settled largely fairly near Richmond (where they established Earlham College) yielded several of the starred scientists of Union, Wayne, and Randolph counties, and also the two from Parke County and the one from Orange County. The Scotch Presbyterians were less concentrated; they yielded several of the 81. Several other Indiana starred scientists had Puritan ancestors. Puritan "stock" has been especially productive of starred scientists, according to the returns from Cattell's 1904 and the present author's 1946 questionnaire, and to much other evidence. Most of the starred scientists born in northern Indiana had Puritan ancestors as did several of those born in southern Indiana.

6. A sixth theory is that outstanding leaders such as the starred scientists come from families that are especially alert, earnest, and ambitious, without respect to their racial backgrounds, and that such people tend to congregate in places of comparative opportunity for them to use their talents. Bits of evidence from the data as to the Indiana starred scientists which supports this theory include: When southeastern Indiana was relatively favored, it produced many leaders, but when, because of the depletion of soil and forest wealth and especially when greater opportunities opened elsewhere, many of the more ambitious

people moved away. As a result, southeastern Indiana has yielded few starred scientists for many years. For example none were born since 1880 in four of the southeastern counties which were especially productive earlier (Crawford, Jefferson, Switzerland or Union counties). Likewise not one was born since 1880 in the entire unglaciated part of the State. Indeed, all 42 counties south of Wayne, Johnson and Vigo have yielded only two since 1881, one born in 1887 (Mann), and the other in 1901 (Twitty). Another evidence of the selective migration of the parents of the starred scientists is that relatively many starred scientists were born in county seats, the local centers of greatest opportunity for talent. The considerable number born in college towns is another evidence. The fact that of the 30 born in Indiana since 1880, 12 were born in the Gas Belt of the late 1880's and 1890's is significant. The boom experienced there attracted relatively many ambitious people. Both of Indiana's Nobel Prize winners, Urey and Stanley, were born in the northern half of the State since 1892.

7. A seventh theory to explain the contrasts in yield of notables is that, from young people with the requisite ability, leaders come if they receive adequate encouragement from those close to them and from stimulating teachers, provided opportunities are afforded to them to develop their talents. Conversely, few become such leaders if sufficiently stimulating teachers are not available, and if they are not encouraged to prepare themselves adequately, and if opportunities to serve as leaders are not available. This theory has much support in Indiana.

Starred Scientists who Obtained College Degrees in Indiana

Of the 81 native starred scientists, 49 obtained their college degrees in Indiana and 31 graduated elsewhere, (one, Mooney, did not graduate). However, those who went elsewhere for their college training were matched by 31 who came from other states or countries to Indiana for their college degrees.

Table 2 shows by science and decade of graduation the number of starred scientists who received college degrees in Indiana. It reveals that 19 zoologists graduated in Indiana, 16 botanists, 13 chemists, 11 physicists, 8 psychologists, 7 astronomers, 2 each of anthropology, mathematics and physiology, 1 each of geology and pathology and none in anatomy. The available data indicate that of the 19 zoologists, 5 were students of David Starr Jordan and 8 studied under students of his who later taught in Indiana. In addition, several of Dr. Jordan's students were later starred in other sciences than zoology and gave him much credit for his having stimulated them to high achievement. Of the 16 botanists, about 5 were students of John Merle Coulter and 4 or 5 were students of his former students who later taught in Indiana. Of the 13 chemists, 4 graduated at DePauw, 2 of them under W. M. Blanchard; 3 graduated at Earlham and one each at Butler, Hanover, Manchester, Notre Dame, Purdue and Valparaiso. Of the 11 physicists, 4 graduated at DePauw, 3 at Indiana, and 2 each at Purdue and Rose

TABLE 2. Indiana colleges starred scientists collegiate alumni
Number by Science and Date of Graduation

	Before 1880	1880-1884	1885-1889	1890-1894	1895-1899	1900-1904	1905-1909	1910-1914	1915-1919	1920-1931
Anthropology	0	0	0	1	1	0	0	0	0	0
Astronomy	0	0	1	1	0	3	2	0	0	0
Botany	3	0	2	6	0	1	2	2	0	0
Chemistry	3	0	0	2	2	1	0	1	0	4
Geology	0	0	0	1	0	0	0	0	0	0
Mathematics	0	0	1	0	0	1	0	0	0	0
Pathology	0	0	1	0	0	0	0	0	0	0
Physics	0	1	0	5	1	1	1	0	0	2
Physiology	0	0	0	0	0	1	0	1	0	0
Psychology	0	1	0	2	0	1	2	1	1	0
Zoology	1	0	4	1	4	5	3	0	0	1
	—	—	—	—	—	—	—	—	—	—
	7	2	9	19	8	14	10	5	1	7

Polytechnic, none elsewhere. Of the 8 psychologists, Indiana graduated 5, Earlham, Evansville and Valparaiso 1 each (Stone graduated from both Valparaiso and Indiana University). Of the 7 astronomers, Indiana graduated 5, of whom 4 were students of the other one, John A. Miller. The remaining 2 were from Rose Poly and Valparaiso. The 2 anthropologists graduated at Earlham and I. U. The 2 mathematicians graduated at I. U. and Purdue; also graduated at I. U. were the 2 physiologists, the geologist, and the pathologist. (The names of these alumni are given in lists 2-5).

Table 2 shows that the number of subsequently starred scientists who obtained their college degree in Indiana fluctuated among the half decades. During 1890-1894, 19 graduated, during the next half-decade 8, but during 1900-1904, 14. Conversely, only 1 graduated 1915-1919, although 7 graduated since 1919. Why not? What happened at Indiana University, for example, which caused it to graduate 5 in 1902 and 8 in 1903-1906 but only two since then? Of 266 men who graduated there in the 1880's, 5 were starred; of the 833 who graduated in the 1890's, 11 were starred; of the approximately 800 who graduated 1900-1906, 14 were starred. For 1907-1929 inclusive about 8000 men were graduated from I. U. Of these only 2 were starred. Thus nearly 2 percent of the graduates of the 1880's later were starred, 1.3 percent of the graduates of the 1890's, 1.6% of those of 1900-1906, less than 0.1% of those of the next decade and none at all since then!

The fluctuation in the proportion of the alumni who subsequently were starred correlates with several conditions, including changes in the faculty, changes in institutional policies, changes in size of enrollments and classes, changes in opportunities, changes in the age of the faculty. The large number of graduates of 1902-1906 who became distinguished scientists clearly merits special consideration. Apparently the coming of W. L. Bryan to the presidency in 1902 and the establishment of the Graduate School aroused hopes and greatly stimulated various students. Why the drastic decline after 1906? Apparently this was partly due to failure of the expectations aroused in 1902 to materialize. Significant also was the sharp increase in enrollments which occurred then, and the relatively great growth of the law school and medical school. Moreover since about 1907 many of the students taking zoology have done so because it is one of the requirements for admission to medical school, not because they were especially interested in zoology. Such students tend to divert students who had planned on becoming scientists. Other factors influencing the decline were the relatively notable advancement in certain other universities, and the greater opportunities in business. (Gary was founded in 1906 and industrialization developed rapidly in Indiana following 1906.) The progressive aging of the faculty also played a part. In 1902, most of the faculty were relatively young. Many of them continued in power, as heads of their departments, for some decades. When President Bryan retired in 1937, at the age of 77, many of the department heads and deans were elderly and, as is true of most elderly persons, no longer optimistic and enthusiastic.

List 2 gives by science and institution the names of the collegiate alumni, with the year of their graduation. (Stone received two bachelors degrees. Pike is listed under both zoology and physiology.)

As a sort of appendix are given 6 lists. List 3 gives by schools their starred alumni; List 4 and 5 give these by year of graduation, with some summary data. List 6 gives, alphabetically, the names of the 81 starred scientists born in Indiana. List 7 gives them by counties. List 8 gives those 31 born elsewhere who received college degrees in Indiana. At the end there is a summary and some conclusions.

LIST 1. INDIANA STARRED SCIENTISTS, BIRTHPLACES BY SCIENCE
With Year of Birth Given After the Name

Anatomy: (2) A Kuntz '79 (Batesville, Ripley Co.,); W. F. Windle '98 (Huntington, Huntington Co.).

Anthropology: (2) J. Mooney '61 (Richmond, Wayne Co.); C. Wissler '70 (Wayne Co.).

Astronomy: (5) C. L. Doolittle '43 (Ontario, Lagrange Co.); J. C. Duncan '82 (Knightstown, Hancock Co.); J. A. Miller '59 (Greensburg, Decatur Co.); Slipher, E.C. '83 & V.M. '75 (Mulberry, Clinton Co.).

Botany: (12) C. R. Barnes '58 (Madison, Jefferson Co.); H. L. Bolley '65 (Holman, Dearborn Co.); O. W. Caldwell '69 (Lebanon, Boone Co.); H. M. Fitzpatrick '86 (Greenwood, Johnson Co.); R. B. Harvey '90 (Monroeville, Morgan Co.); D. T. MacDougal '65 (Liberty, Union Co.); G. T. Moore '71 (Indianapolis, Marion Co.); D. M. Mottier '64 (Patriot, Switzerland Co.); E. W. Olive '70 (Lebanon, Boone Co.); J. N. Rose '62 (Union Co.); J. R. Schramm '85 (Hancock Co.); H. H. Whetzel '77 (near Avilla, Noble Co.).

Chemistry: (11) R. F. Bacon '80 (Muncie, Delaware Co.); G. L. Clark '92 (Anderson, Madison Co.); A. C. Cope '09 (Dunreith, Henry Co.); M. R. Fenske '04 (Michigan City, LaPorte Co.); C. A. Kraus '75 (Knightsville, Clay Co.); S. A. Lattimore '28 (Liberty, Union Co.); H. N. McCoy '70 (Richmond, Wayne Co.); W. A. Noyes, Jr. '98 (Terre Haute, Vigo Co.); L. I. Smith '91 (Indianapolis, Marion Co.); W. M. Stanley '04 (Ridgeville, Randolph Co.); H. W. Wiley '44 (Kent, Jefferson Co.)

Geology: (6) H. F. Bain '71 (Seymour, Jackson Co.); C. P. Berkey '69 (Goshen, Elkhart Co.); O. P. Hay '46 (Jefferson Co.); E. M. Kindle '69 (Franklin, Johnson Co.); P. B. King '03 (Richmond, Wayne Co.); F. B. Taylor '60 (Ft. Wayne, Allen Co.).

Mathematics: (4) O. E. Glenn '78 (Moorefield, Switzerland Co.); E. R. Hedrick '76 (Union City, Randolph Co.); D. N. Lehmer '67 (Somerset, Wabash Co.); J. B. Shaw '66 (Remington, Jasper Co.).

Pathology: (4) J. S. Billings '38 (Switzerland Co.); G. F. Dick '81 (Fort Wayne, Allen Co.); T. Francis, Jr. '00 (Gas City, Grant Co.); A. S. Warthin '66 (Greensburg, Decatur Co.).

Physics: (7) L. A. DuBridge '01 (Terre Haute, Vigo Co.); A. L. Foley '67 (Hancock Co.); W. H. Furry '07 (Prairietown, Vigo Co.); E. Merritt '65 (Indianapolis, Marion Co.); W. B. Nottingham '99 (Tipton, Tipton Co.); J. O. Reed '56 (Newcastle, Henry Co.); H. C. Urey '93 (Walkerton, St. Joseph Co.).

Physiology: (3) R. Burton-Opitz '75 (Ft. Wayne, Allen Co.); C. W. Greene '66 (Crawford Co.); F. C. Mann '87 (Decatur, Adams Co.).

Psychology: (7) G. W. Allport '97 (Montezuma, Parke Co.); W. L. Bryan '60 (Bloomington, Monroe Co.); J. F. Dashiell '88 (Southport, Marion Co.); E. H. Lindley '69 (Paoli, Orange Co.); E. D. Starbuck '66 (Bridgeport, Marion Co.); C. P. Stone '92 (Portland, Jay Co.); L. M. Terman '77 (Johnson Co.).

Zoology: (19) W. C. Allee '85 (Bloomingdale, Parke Co.); B. M. Allen '77 (Greencastle, Putnam Co.); A. M. Banta '77 (Greenwood, Johnson Co.); G. N. Calkins '69 (Valparaiso, Porter Co.); C. Grave '70 (Monrovia, Morgan Co.); C. W. Hargitt '52 (Lawrenceburg, Dearborn Co.); G. T. Hargitt '81 (Fairfield, Franklin Co.); O. P. Hay '46 (Jefferson Co.); H. Heath '68 (Vevay, Switzerland Co.); W. T. Hornaday '54 (Plainfield, Hendricks Co.); C. Juday '71 (Ligonier, Noble Co.); C. H. Kennedy '79 (Rockport, Spencer Co.); W. L. McAtee '83 (Jalapa, Grant Co.); N. E. McIndoo '81 (Lyons, Greene Co.); W. J. Moenkhaus '71 (Huntingburg, DuBois Co.); F. Payne '81 (Shelbyville, Shelby Co.); J. Reighard '61 (LaPorte Co.); O. Riddle '77 (Crawford Co.); V. C. Twitty '01 (Martin Co.).

LIST 2. STARRED COLLEGIATE ALUMNI OF INDIANA BY SCIENCE

Anthropology: *Earlham:* Goddard, P. E. '92; *Indiana:* Wissler, C. '97.

Astronomy: *Indiana:* Duncan, J. C. '05; Lampland, C. O. '02; Miller, J. A. '90; Slipher, E. C. '06; Slipher, V. M. '01. *Rose Polytechnic Inst.:* Parkhurst, J. A. '86; *Valparaiso:* Anderson, J. A. '00.

Botany: *DePauw:* MacDougal, D. T. '90; *Earlham:* Petry, L. D. '07; *Franklin:* Caldwell, O. W. '94; *Hanover:* Barnes, C. R. '77; Coulter, J. M. '70; Coulter, S. '77 *Indiana:* Bray, W. L. '93; Mottier, D. M. '91; *Purdue:* Bolley, H. L. '88; *Valparais :* LaRue, C. D. '10; *Wabash:* Moore, G. T. '94; Olive, E. W. '93; Reddick, D. '05; Rose, J. N. '85; Schramm, J. R. '10; Whetzel, H. H. '02.

Chemistry: *Butler:* Cope, A. C. '29; *DePauw:* Bacon, R. F. '99; Clark, G. L. '14; Fenske, M. R. '25; Lattimore, S. A. '50; *Earlham:* Howe, H. E. '01; Stanley, W. M. '26; Warder, R. B. '66; *Hanover:*

Wiley, H. W. '67; *Manchester:* Flory, P. J. '31; *Notre Dame:* Nieuwland, J. A. '99; *Purdue:* McCoy, H. N. '92; *Valparaiso:* Teeple, J. E. '93.

Geology: *Indiana:* Kindle, E. M. '93.

Mathematics: *Indiana:* Glenn, O. E. '02; *Purdue:* Shaw, J. B. '89.

Pathology: *Indiana:* Warthin, A. S. '88.

Physics: *DePauw:* Furry, W. H. '28; Longden, A. C. '81; Stewart, G. W. '98; Stewart, O. M. '92; *Indiana:* Brown, F. C. '04 Foley, A. L. '90; Knipp, C. T. '94; *Purdue:* Luckiesh, M. '09; Nottingham, W. B. '20; *Rose Polytech. Inst.:* Johonnott, E. S. '93; Mendenhall, C. E. '94.

Physiology: *Indiana:* Mann, F. C. '11; Pike, F. H. '03.

Psychology: *Earlham:* Mills, W. R. '08; *Evansville:* Dashiell, J. F. '08; *Indiana:* Bryan, Wm. L. '84; Lindley, E. H. '93; Starbuck, E. D. '90; Stone, C. P. '15; Terman, L. M. '02; *Valparaiso:* Stone, C. P. '10.

Zoology: *Butler:* Gilbert, C. H. '79; Twitty, V. C. '25; *DePauw:* Allen, B. M. '98; McFarland, F. M. '89; Riley, W. A. '97; *Earlham:* Allee, W. C. '08; Grave, C. '95; *Indiana:* Banta, A. M. '03; Edwards, C. L. '86; Eigenmann, C. H. '86; Evermann, B. W. '86; Juday, C. '96; Kennedy, C. H. '02; McAtee, W. L. '04 McIndoo, N. E. '06; Moenkhaus, W. J. '94; Payne, F. '05; Pike, F. H. '03; Riddle, O. '02.

LIST 3. STARRED COLLEGIATE ALUMNI OF INDIANA SCHOOLS

Butler: (3) *Chemistry:* Cope, A. C. '29 *7; *Zoology:* Gilbert, C. H. '79 *1; Twitty, V. C. '25 *6.

DePauw: (12) *Botany:* MacDougal, D. T. '90 *1; *Chemistry:* Bacon, R. F. '99 *3; Clark, G. L. '14 *5; Fenske, M. R. '25 *7; Lattimore, S. A. '50 *1; *Physics:* Furry, W. H. '28 *7; Longden, A. C. '81 *1; Stewart, G. W. '98 *1; Stewart, O. M. '92 *1; *Zoology:* Allen, B. M. '98 *2; McFarland, F. M. '89 *1; Riley, W. A. '97 *5.

Earlham: (8) *Anthropology:* Goddard, P. E. '92 *3; *Botany:* Petry, L. D. '07 *6; *Chemistry:* Howe, H. E. '01 *3; Stanley, W. M. '26 *7; Warder, R. B. '66 *1; *Psychology:* Miles, W. R. '08 *4; *Zoology:* Allee, W. C. '08 *3; Grave, C. '95 *1.

Evansville: (1) *Psychology:* Dashiel, J. F. '08 *5.

Franklin: (1) *Botany:* Caldwell, O. W. '94 *2.

Hanover: (4) *Botany:* Barnes, C. R. '77 *1; Coulter, J. M. '70 *1; Coulter, S. '77 *1; *Chemistry:* Wiley, H. W. '67 *1.

Indiana: (32) *Anthropology:* Wissler, C. '97 *1; *Astronomy:* Duncan, J. C. '05 *6; Lampland, C. O. '02 *3; Miller, J. A. '90 *3; Slipher, E. C. '06 *5; Slipher, V. M. '01 *3; *Botany:* Bray, W. L. '93 *1; Mottier, D. M. '91 *1; *Geology:* Kindle, E. M. '93 *3; *Mathematics:*

Glenn, O. E. '02 *3; *Pathology:* Warthin, A. S. '88 *1; *Physics:* Brown, F. C. '04 *3; Foley, A. L. '90 *1; Knipp, C. T. '94 *1; *Physiology:* Mann, F. C. '11 *4; Pike, F. H. '03 *3; *Psychology:* Bryan, Wm. L. '84 *1; Lindley, E. H. '93 *1; Starbuck, E. D. '90 *2; Stone, C. P. '15 *5; Terman, L. M. '02 *3; *Zoology:* Banta, A. M. '03 *3; Edwards, C. L. '86 *1; Eigenmann, C. H. '86 *1; Evermann, B. W. '86 *2; Juday, C. '96 *4; Kennedy, C. H. '02 *7; McAtee, W. L. '04 *6; McIndoo, N. E. '06 *7; Moenkhaus, W. J. '94 *2; Payne, F. '05 *3; Pike, F. H. '03 *3; Riddle, '02 *3.

Manchester: (1) *Chemistry:* Flory, P. J. '31 *7.

Notre Dame: (1) *Chemistry:* Nieuwland, J. A. '99 *5.

Purdue: (5) *Botany:* Bolley, H. L. '88 *1; *Chemistry:* McCoy, H. N. '92 *2; *Mathematics:* Shaw, J. B. '89 *1; *Physics:* Luckiesh, M. '09 *3; Nottingham, W. B. '20 *7.

Rose Polytechnic Institute: (3) *Astronomy:* Parkhurst, J. A. '86 *2; *Physics:* Johonnott, E. S. '93 *2; Mendenhall, C. E. '94 *1.

Valparaiso: (4) *Astronomy:* Anderson, J. A. '00 *3; *Botany:* LaRue, C. D. '10 *6; *Chemistry:* Teeple, J. E. '93 *4; *Psychology:* Stone, C. P. '10 *5.

Wabash: (6) *Botany:* Moore, G. T. '94 *1; Olive, E. W. '93 *2; Reddick, D. '05 *3; Rose, J. N. '85 *1; Schramm, J. R. '10 *3; Whetzel, H. H. '02 *3.

LIST 4. STARRED COLLEGIATE ALUMNI
By School and Year of Graduation

Butler: (3) 1879 Gilbert; 1925 Twitty; 1929 Cope.

Depauw: (12) 1850 Lattimore; 1881 Longden; 1889 McFarland; 1890 MacDougal; 1892 Stewart, O. M.; 1897 Riley; 1898 Allen; Stewart, G. W.; 1899 Bacon; 1914 Clark; 1925 Fenske; 1928 Furry.

Earlham: (8) 1866 Warder; 1892 Goddard; 1895 Grave; 1901 Howe; 1907 Petry; 1908 Allee; Miles; 1926 Stanley.

Evansville: (1) 1908 Dashiell.

Franklin: (1) 1894 Caldwell.

Hanover: (4) 1867 Wiley; 1870 Coulter, J. M.; 1877 Barnes; Coulter, S.

Indiana: (32) 1884 Bryan; 1886 Edwards; Eigenmann; Evermann; 1888 Warthin; 1890 Foley; Miller; Starbuck; 1891 Mottier; 1893 Bray; Kindle; Lindley; 1894 Knipp; Moenkhaus; 1896 Juday; 1897 Wissler; 1901 Slipher, V. M.; 1902 Glenn; Kennedy; Lampland; Riddle; Terman; 1903 Banta; Pike; 1904 Brown; McAtee; 1905 Duncan; Payne; 1906 McIndoo; Slipher, E. C.; 1911 Mann; 1915 Stone.

Manchester: (1) 1931 Flory.

Notre Dame: (1) 1899 Nieuwland.

Purdue: (5) 1888 Bolley; 1889 Shaw; 1892 McCoy; 1909 Luckiesh; 1920 Nottingham.

Rose Polytechnic Institute: (3) 1886 Parkhurst; 1893 Johnnott; 1894 Mendenhall.

Valparaiso: (4) 1893 Teeple; 1900 Anderson; 1910 LaRue; Stone.

Wabash (6) 1885 Rose; 1893 Olive; 1894 Moore; 1902 Whetzel; 1905 Reddick; 1910 Schramm.

LIST 5. STARRED COLLEGIATE ALUMNI OF INDIANA BY CLASS

1850 Lattimore, S. A. 1866 Warder, R. B. 1867 Wiley, H. W. 1870 Coulter, J. M. 1877 Barnes, C. R.; Coulter, S. 1879 Gilbert, C. H. 1881 Longden, A. C. 1884 Bryan, Wm. L. 1885 Rose, J. N.; 1886 Edwards, C. L.; Eigenmann, C. H.; Evermann, B. W.; Parkhurst, J. A. 1888 Bolley, H. L.; Warthin, A. S. 1889 McFarland, F. M.; Shaw, J. B. 1890 Foley, A. L.; MacDougal, D. T.; Miller, J. A. Starbuck, E. D. 1891 Mottier, D. M. 1892 Goddard, P. E.; McCoy, H. N.; Stewart, O. M. 1893 Bray, W. L.; Johonnott, E. S.; Kindle, E. M.; Lindley, E. H.; Olive, E. W.; Teeple, J. E. 1894 Caldwell, O. W.; Knipp, C. T.; Mendenhall, C. E.; Moenkhaus, W. J.; Moore, G. T. 1895 Grave, C. 1896 Juday, C. 1897 Riley, W. A.; Wissler, C. 1898 Allen, B. M.; Stewart, G. W.

1899 Bacon, R. F.; Nieuwland, J. A. 1900 Anderson, J. A. 1901 Howe, H. E.; Slipher, V. M. 1902 Glenn, O. E.; Kennedy, C. H.; Lampland, C. O.; Riddle, O.; Terman, L. M.; Whetzel, H. H. 1903 Banta, A. M.; Pike, F. H. 1904 Brown, F. C.; McAtee, W. L. 1905 Duncan, J. C.; Payne, F.; Reddick, D. 1906 McIndoo, N. E.; Slipher, E. C. 1907 Petry, L. D. 1908 Allee, W. C.; Dashiell, J. F.; Miles, W. R. 1909 Luckiesh, M. 1910 LaRue, C. D.; Schramm, J. R.; Stone, C. P. 1911 Mann, F. C. 1914 Clark, G. L. 1915 Stone, C. P. 1920 Nottingham, W. B. 1925 Fenske, M. R.; Twitty, V. C. 1926 Stanley, W. M. 1928 Furry, W. H. 1929 Cope, A. C. 1931 Flory, P. J.

Before 1870 3; 1870's 4; 1880-84 2; 1885-89 9; 1890-94 19; 1895-99 8; 1900-04 12; 1905-09 10; 1910-14 5; 1915-19 0; 1920-24 1; 1925-29 4; 1930-1.

Every year 1884-1914 had 1 to 6.
Since 1914 only 7 have graduated, 6 of them 1915-1931.
The high years were 1893 and 1902, 6 each; 1894 5, in 1886 and 1890 4, and 3 each in 1905, 1908, 1910.

LIST 6. STARRED SCIENTISTS BORN IN INDIANA

Arranged Alphabetically; Year of Birth

Allee, W. C. '85; Allen, B. M. '77; Allport, G. W. '97; Bacon, R. F. '80; Bain, H. F. '71; Banta, A. M. '77; Barnes, C. R. '58; Berkey, C. P. '67;

Billings, J. S. '38; Bolley, H. L. '65; Bryan, W. L. '60; Burton-Opitz, R. '75; Caldwell, O. W. '69; Calkins, G. N. '69; Clark, G. L. '92; Cope, A. C. 1909; Dashiell, J. F. '88; Dick, G. F. '81; Doolittle, C. L. '43; DuBridge, L. A. 1901; Duncan, J. C. '82; Fenske, M. R. 1904; Fitzpatrick, H. M. '86; Foley, A. L. '67; Francis, T., Jr. 1900; Furry, W. H. 1907; Glenn, O. E. '78; Grave, C. '70; Greene, C. W. '66; Hargitt, C. W. '52; Hargitt, G. T. '81; Harvey, R. B. '90; Hay, O. P. '46; Heath, H. '68; Hedrick, E. R. '76; Hornaday, W. T. '54.

Juday, C. '71; Kennedy, C. H. '79; Kindle, E. M. '69; King, P. B. 1903; Kraus, C. A. '75 Kuntz, A. '79; Lattimore, S. A. '28; Lehmer, D. N. '67; Lindley, E. H. '69; MacDougal, D. T. '65; Mann, F. C. '87; McAtee, W. L. '83; McCoy, H. N. '70; McIndoo, N. E. '81; Merritt, E. '65; Miller, J. A. '59; Moenkhaus, W. J. '71; Mooney, J. '61; Moore, G. T. '71; Mottier, D. M. '64; Nottingham, W. B. '99; Noyes, W. A., Jr. '98; Olive, E. W. '70; Payne, F. '81; Reed, J. O. '56; Reighard, J. '61; Riddle, O. '77; Rose, J. N. '62 Schramm, J. R. '85; Shaw, J. B. '66; Slipher, E. C. '83; Slipher, V. M. '75; Smith, L. I. '91; Stanley, W. M. 1904; Starbuck, E. D. '66 Stone, C. P. '92; Taylor, F. B. '60; Terman, L. M. '77; Twitty, V. C. 1901; Urey, H. C. '93; Warthin, A. S. '66; Whetzel, H. H. '77; Wiley, H. W. '44 Windle, W. F. '98; Wissler, C. '70.

LIST 7. STARRED SCIENTISTS BORN IN INDIANA

Arranged by Counties

Adams: Mann; *Allen:* Burton-Opitz, Dick, Taylor; *Boone:* Caldwell, Olive; *Clay:* Kraus; *Clinton:* Slipher, E. C. and V. M.; *Crawford:* Greene, Riddle; *Dearborn:* Bolley, Hargitt, C. W.; *Decatur:* Miller, Warthin; *Delaware:* Bacon; *Dubois:* Moenkhaus; *Elkhart:* Berkey; *Franklin:* Hargitt, G. T.; *Grant:* Francis, McAtee; *Greene:* McIndoo; *Hancock:* Duncan, Foley, Schramm; *Hendricks:* Hornaday; *Henry:* Cope, Reed; *Huntington:* Windle; *Jackson:* Bain; *Jasper:* Shaw; *Jay:* Stone; *Jefferson:* Barnes, Hay, Wiley; *Johnson:* Banta, Fitzpatrick, Kindle, Terman; *LaGrange;* Doolittle; *LaPorte;* Fenske, Reighard; *Madison:* Clark; *Marion:* Dashiell, Merritt, Moore, Smith, Starbuck; *Martin:* Twitty; *Monroe:* Bryan; *Morgan:* Grave, Harvey; *Noble:* Juday, Whetzel; *Orange:* Lindley; *Parke:* Allee, Allport; *Porter:* Calkins; *Putnam:* Allen; *Randolph:* Hedrich, Stanley; *Ripley:* Kuntz; *St. Joseph:* Urey; *Shelby:* Payne; *Spencer:* Kennedy; *Switzerland:* Billings, Glenn, Heath, Mottier;*Tipton:* Nottingham; *Union:* Lattimore, MacDougal, Rose; *Vigo:* DuBridge, Furry, Noyes; *Wabash:* Lehmer; *Wayne:* King, McCoy, Mooney, Wissler.

LIST 8. STARRED SCIENTISTS WHO CAME TO INDIANA FOR THEIR COLLEGE DEGREES

Anderson, J. A.; Bray, W. L.; Brown, F. C.; Coulter, J. M.; Coulter, Stanley; Edwards, C. L.; Eigenmann, C. H.; Everman, B. W.; Flory, P. J.; Gilbert, G. H.; Goddard, P. E.; Johonnott, E. S.; Howe, H. E.; Knipp, C. T.; Lampland, C. O.; LaRue, C. D.; Longden, A. C.; Luckiesh, M.; McFarland, F. M.; Mendenhall, C. E.; Miles, W. R.; Nieuwland, J. A.; Parkhurst, J. A.; Petry, L. D.; Pike, F. H.; Reddick, D.; Riley, W. A.; Stewart, G. W.; Stewart, O. M.; Teeple, J. E.; Warder, R. B.

Summary and Conclusions

Indiana was the native state of 81 scientists starred in the biographical directory, "American Men of Science," (by secret vote of their fellow scientists) as especially distinguished in research. Each of the 12 sciences in which starring has been done have had 2 or more representatives born in Indiana; zoology had 19, botany 12, chemistry 11, physics 7, geology 6, psychology 6, astronomy 5, mathematics and pathology 4 each, physiology 3, and anatomy and anthropology 2 each, For 7 sciences, Indiana surpassed more than three-fourths of the 48 states in the yield of starred scientists per million of population at about the date of their birth. For 3 sciences (anatomy, chemistry and mathematics) it surpassed two-thirds of the states and it stood only a little lower for geology. Only for physics was it surpassed by slightly more than half of the states.

The birthplaces of these scientists are very unequally distributed over the state. In brief, of those born before 1880, the southeastern part of the state led by a wide margin, but of those born since 1880 the southern part of the state yielded few. Contrasts among the counties and sections of the state are presented in some detail, and several possible explanations of the contrasts are offered.

Indiana institutions conferred college degrees upon 81 subsequently starred scientists, 31 of whom were born elsewhere. By institutions Indiana University graduated 32, DePauw 12, Earlham 8, Wasbash 6, Purdue 5, Hanover and Valparaiso 4, Butler and Rose 3, and Evansville, Franklin, Manchester, and Notre Dame 1 each. Considerable evidence, summarized in the paper, indicates that personal encouragement by enthusiastic, stimulating teachers was an important influence in the output of subsequently starred scientists. For example, 13 of the 19 zoologists were students of David Starr Jordan or of men started by him. In addition, several of Dr. Jordan's students were starred in other sciences. Of the 16 botanists, about 10 were students of John Merle Coulter or of students of his. John A. Miller trained most of the astronomers. W. M. Blanchard trained 2 of the chemists. Conversely, despite very large enrollments in chemistry for many decades, only one Purdue alumnus has been starred in chemistry and none from Indiana University. This suggests that large classes, sort of mass production methods, are not conducive to stimulating young people to become scholars. What is needed in addition to able students is individual attention and personal encouragement.

MATHEMATICS

Chairman: L. H. Whittcraft, Ball State Teachers College

Paul Overman, Purdue University, was elected chairman for 1949.

ABSTRACTS

PHYSICS

Chairman: J. C. Hendrics, Franklin College

Ancil R. Thomas, Valparaiso University, was elected chairman for

ABSTRACTS

Metastable Atomic States in Gas Discharges. K. W. Meissner, Purdue University.—The behaviour of a discharge through gases can be considerably influenced by the presence of atoms in metastable states. A simple experiment with a glow discharge in very pure neon strikingly shows such an influence in the following manner.

A glow discharge is maintained in a simple discharge tube of 25 millimeter diameter and 150 millimeter length which has been filled with very pure neon of about 5 mm Hg. The operating voltage is chosen in such a way that the discharge remains just stable. As soon as the glowing neon tube is irradiated with light of an intensive neon discharge tube the glow discharge becomes unstable and goes out. The explanation of this behaviour can be found in the fact that the number of metastable atoms is greatly reduced by absorption of certain wavelengths of the irradiating source.

Investigations With a Reflection Echelon Grating. Delmar O. Davis, K. W. Meisner, Purdue University.—The performance of a reflection echelon grating made by Adam Hilger, Ltd., London, was investigated.

The possibility of changing from a "double-order" pattern to a "single-order" pattern by changing the geometrical conditions instead of the commonly used change of air pressure is discussed and the idea was tested experimentally. It was found that a slight change of the angle of incidence allows one to produce a change of a whole order. This fact is of great importance for investigations in the vacuum ultraviolet.

The accuracy of wave length measurements is not affected by the choice of the angle of incidence as was shown by wave length measurements of krypton and neon lines.

Last, the effective resolving power of the reflection echelon was determined by using the Zeeman effect of the 5570 A krypton line. The smallest Zeeman splitting which could be resolved by the echelon was taken as the limit of resolution. It was found that the reflection echelon achieves, in practice, the theoretical resolving power.

Neutron Diffraction by Ice Crystals. HUBERT M. JAMES, Purdue University.—X-ray studies have established the positions of the oxygen atoms in ice crystals, but determination of the positions of the hydrogen atoms has not been possible. Neutron diffraction offers a powerful method for locating the hydrogen atoms, but interpretation of the diffraction patterns obtained by Wollan and Shull at Oak Ridge has offered difficulties which are apparently connected with other peculiarities in the behavior of ice—the presence of unexplained diffuse bands in the X-ray spectrum, and the unexpectedly large value of the entropy. It is known that each oxygen atom has four oxygen neighbors, tetrahedrally arranged, and on each oxygen-oxygen line one must expect to find one hydrogen atom. Pauling has accounted for the observed entropy of ice by assuming that each hydrogen atom can occupy two alternative and unsymmetrical positions with equal probabilities, subject to the condition that of the four hydrogen neighbors of each oxygen, two must be in the position nearer to this oxygen, and two in the more remote positions. A calculation has been made of the neutron diffraction patterns to be expected for a single ice crystal, on Pauling's model. This consists of three parts:

> (a) Laue spots, with intensities predictable by assigning half the scattering amplitude of each hydrogen nucleus to the two alternative positions for that nucleus.
>
> (b) A continuous background arising from the randomness in the arrangement of the hydrogen muclei.
>
> (c) A background showing some structure due to the correlations established between the positions of hydrogen atoms by the condition that each oxygen atom shall have exactly two close hydrogen neighbors.

Dr. Wollan informs the author that the observed intensities of the Laue spots agree well with this prediction.

The Determination of the Deflective Curve of a Vibrating Beam by Means of Bonded Strain Gages. B. E. QUINN and JAMES E. BROCK, Purdue University.—An experimental method is described for securing strain vs. time records at significant points along a vibrating beam by means of bonded strain gages. A simple transformation gives

$$\frac{d^2y}{dx^2} = \frac{\epsilon}{c}$$

where ϵ is strain and c is the distance from the neutral axis to the extreme fiber. If we plot ϵ/c vs. length for any instant, then it is possible by means of two successive graphical integrations to plot the deflection curve. The determination of other properties of the vibrating beam from the ϵ/c vs. length curve is also explained.

PSYCHOLOGY

Chairman: Douglas G. Ellison, Indiana University

E. J. Asher, Purdue University, was elected chairman for 1949.

ABSTRACTS

Application of Servo Theory to Human Motor Behavior. D. G. Ellson, Indiana University.—Servo theory was developed by engineers and mathematicians to aid in the design of mechanical and electrical transmission systems and amplifiers. With the aid of this theory the performance of a complex transmission system can be improved by designing one component so that its performance characteristics match certain characteristics of other components. "Noise" or errors introduced by one component can be eliminated or filtered out by suitable design of other components.

A man operating certain types of machines such as an automobile, an airplane, or a gunsight may be considered as one component of a complex system which includes both the man and the machine. If the man's response in operating the machine has the necessary characteristics for the application of servo theory, then it may be possible to eliminate the errors which the man makes by proper design of the machine he operates. The psychological problem on which research is being done at present is the investigation of the response characteristics necessary for this application.

A Re-Test of Adolescents' Interpretations of Emotionally-toned Situations After Two Years. Alma Long, Purdue University.—Comparison of responses of 76 youths whose records were part of the large number studied for development of measuring devices, after a period of two years. Original classification in grades 7-10. Identical materials and methods for test-retesting.

Studied for indications of consistency in individual response, extent and nature of change, implications for school and counselling needs. About one third of group (1) Maintained same relative rank in group, (2) Progressed farther than average for age-grade group, (3) Lost ground in social position, respectively.

Change in relative position showed little relationship to differences in intelligence ranking or to measures of home quality. Nature of responses, where serious loss in relative position occurred, indicates need for much greater knowledge about and attention to the social needs and personal satisfactions of high school pupils, and to those of the younger pupils in particular.

Prediction of the Relationship Between Test Score and Inconsistency of Response, Robert Glaser, Indiana University.—In psychophysical measurement as the discrimination of a stimulus becomes more difficult,

i. e. as an individual's threshold is approached from either direction on the scale of measurement, his responses become less consistent. The threshold (50%) is defined as the point of greatest inconsistency of response. Test items considered as stimuli similar to the stimuli employed in psychophysical measurement may also evoke an increased inconsistency of response as the individual approaches the point where his response changes from "yes" to "no" or from "right" to "wrong."

If test items are considered in this manner certain hypotheses can be developed concerning the relationship between inconsistency of response to test items (as measured by test-retest) and test score. It can be shown that under certain conditions a spurious correlation may result between inconsistency and test score even when it is assumed that no true relationship exists between the two. The analysis throws doubt upon the results of previous studies which report inconsistency as a trait of behavior correlation with intelligence and personality factors.

Validation of Personality Test Results Against Laboratory Behavior. LAWRENCE M. BAKER and JANE S. HARRIS, Purdue University.—The purpose of the experiment was to compare results obtained by the use of the Rorschach Test and the Minnesota Multiphasic Personality Inventory with certain changes in speech performance under normal and stressful conditions. Fourteen subjects were used and several correlations were run. The most significant were the comparisons of form quality and form-color integration with speech intelligibility and variations of voice intensity. Those individuals whose Rorschach record would indicate greatest emotional instability were most disturbed under stress as indicated by a decrement in speech performance. Those subjects having the high Psychosis score on the MMPI test were found to reflect the least indication of disturbance under stress.

Operant Conditioning of a Vegetative Human Organism. PAUL R. FULLER, Indiana University.—In this study a response was conditioned and subsequently extinguished in a so-called "vegetative" human subject. The methods employed were similar to those used by Skinner and others in experiments with rats and pigeons. The subject was the inmate of a feeble-minded institution who had spent his entire nineteen years in a near-vegetative state. His behavior consisted of limited arm movements, opening his mouth, swallowing, blinking, making some vocal noises, and moving his head.

The response conditioned was the elevation of the right arm to a vertical or near-vertical position. The right arm was selected because in a preliminary count it was ascertained that the right arm was elevated only half as frequently as the left. The subject was deprived of food for fourteen hours. The rate of elevation of his right arm was ascertained and considered the base line on which subsequent rates of responding were compared. Thereafter every elevation of the right arm was followed immediately by the injection of several cc. of a sugar and milk solution into the mouth of the subject. With repeated occurence of the response followed by the presentation of the reinforcing stimulus, the rate of response increased until it was more than four times the original rate. When the reinforcing stimulus was no longer presented, the rate of response remained high for a period, then decreased, forming a pattern typical of the extinction curves obtained from infra-human organisms under similar conditions.

A Test for an Assumed Property of the Hypothetical Construct of "Fear": An Attempt to Obtain Conditioned Inhibition of the GSR. H. Coppock, Indiana University.—Many experiments in animal learning which have involved electric shock have been interrelated by assuming a motivational factor of fear or tension. This factor is aroused by shock or by stimuli paired therewith, and is reduced by shock termination or by stimuli paired therewith. The reduction of this fear drive is said to constitute reward, which is the strengthening of any preceeding skeletal response.

Stimuli paired with shock termination have been found to become secondary rewards for rats. Presumably such stimuli have become (conditioned) fear reducers. Insofar as fear may be indicated by measurements of the activity of the sympathetic nervous system, as some have asserted that it may be, then these stimuli should have become conditioned inhibitors of sympathetic activity. This was tested with human subjects, using the level of palmar skin resistance as an index of sympathetic activity.

A stimulus (CS) was presented one-half second before the terminations of ten mild shocks of variable duration. Subsequent tests showed that the GSR elicited by this CS was not smaller after than before these trials. The same number of trials was sufficient, however, to condition the CS to the GSR when CS had preceeded the shocks by one-half second.

It is concluded that "fear" is readily conditioned, although fear reduction or tension reduction is not readily, if at all conditionable.

Report of the Remedial Reading Clinic, Blair Wilson Sparks, Butler University.—Students for remedial reading instruction were selected on the basis of their performance on the reading section of the Cooperative English Test which was given to all entering freshman September 16, 1947. All students whose reading scores on this test fell at or below the tenth percentile according to the test norms, were assigned to the reading clinic.

Upon entering the clinic, the students were immediately given the Iowa Silent Reading Test, form DM. This test was administered for diagnostic purposes and was used later in conjunction with form CM of the same test which was given at the end of the instructional period as a means for determining student progress.

Reading instruction consisted, in part, of the use of the Harvard Developmental Reading Program. The program includes fifteen reading films and fifteen equated reading selections. Rate and comprehension scores were selected for each film and reading selection and each student kept a complete record of his achievement on the films and reading selection tests.

The median score attained on the final test was 176.47 whereas the median score on the entering test was 164.56. This shows a gain of 11.80. Furthermore 86.5 percent of the cases exceeded the median on the first test and 68.0 percent of the students on the final test exceeded Q3 of the first test.

The median score attained in the reading rate in September was 260.14 and rose to 497.08 in January. This shows a gain of 239.64. The gain in comprehension accompanying the rise in rate was .55. There were 51.20 percent of the cases which exceeded the September median on comprehension.

Psychology as a Normative Science, CHARLES C. JOSEY, Butler University.—Psychologists have shown considerable interest in what men desire, but have neglected to make serius inquiry into what men should desire. Many confused persons are asking, "What should I do?" Granted that psychologists have no method of discovering the good beyond those available to the thoughtful and observant person, yet it does not seem unreasonable to expect those who specialized in the study of human nature to gain some insight into what constitutes man's highest good. An explanation of why psychologists have neglected this aspect of human nature, and some suggestions for making the needed inquiry are offered.

ZOOLOGY

Chairman: JOHN W. BAECHLE, C.P.P.S., St. Joseph's College

Murven R. Garner, Earlham College, was elected chairman for 1949.

ABSTRACTS

Impedance—Frequency Measurements on Cattle Semen. J. C. HENDRICKS, Franklin College.—Small organisms exhibit electrical polarity while alive and the electric moment has been found in some cases to be a function of the health and virility of the specimen. When large numbers of such organisms are suspended in a solution, the impedance of the suspension should vary with frequency much as it does for a polar liquid. This suggests that the number and virility of the spermatozoa suspended in semen should affect the impedance—frequency relation. Such a relation would be of value as a test for the effectiveness of bulls used in artificial insemination programs.

The conductance cell used consisted of graphite electrodes 2mm apart having a cross sectional area of 5 cm^2. Potential was supplied by an audio or an intermediate frequency oscillator. Potential difference applied to the cell was measured by a vacuum tube voltmeter and the current through the cell by a vacuum thermocouple. The current densities used range from 1 to 20 milliamperes per square centimeter.

It was found that the impedance—frequency curves for semen containing large numbers of active sperms varied markedly in the 20 to 50 kc range from (1) semen containing few live sperms, (2) semen in which the sperm activity was low and (3) semen which had been diluted for insemination purposes. The slope of the curves in this frequency range may prove to be an indicator of the value of the semen for insemination purposes.

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